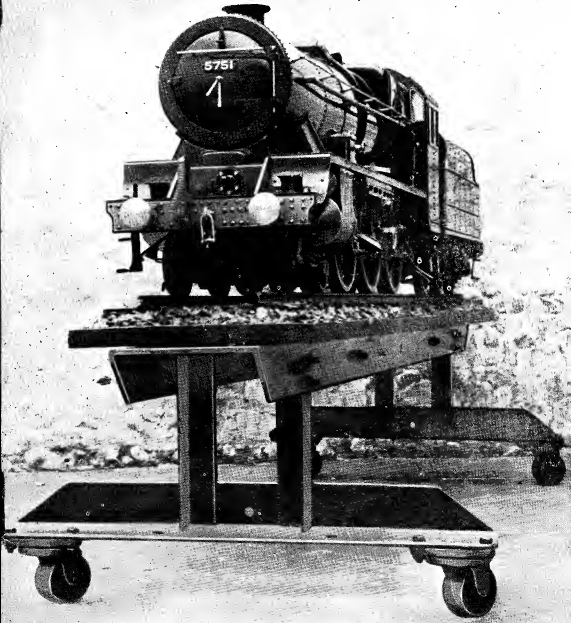
THE MODEL ENGINEER



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The MODEL ENGINEER

PERCIVAL MARSHALL & CO. LTD., 23, GREAT QUEEN ST., LONDON, W.C.2

24TH MARCH 1949 VOL. 100 NO. 2496

SMOKE RINGS

Our Cover Picture

● LARGE-SCALE miniature locomotives are usually very awkward to transport from or to the track, due to their weight and bulk, especially when the running track happens to be elevated. Our photograph this week illustrates a very handy device in the form of a transporter unit built by Mr. J. I. Austen-Walton and used for wheeling his 5-in. gauge locomotive, *Centaur*, out of the shed. The unit couples up directly to the running track, and so avoids the need for heavy lifting. It has proved itself to be very satisfactory over quite a long period of service.

"The Salt of the Earth"

● A GNARLED old engineer—a Scotsman—once slapped a young apprentice on the back and said: "Engineers, laddie, are the salt of the earth. They're the men who make things!"

What a world of truth lay in that statement. But for the work of engineers, our standards of life might still be those of the Middle Ages.

We are sometimes apt to regard the progress made in the various professions which contribute to our wellbeing, such as medical science, as self-contained; such, however, is not the case. Without the apparatus, instruments and heating, all produced by engineers, little if any advancement could have been achieved.

It is generally acknowledged that the invention of printing, which made possible the wide dissemination of accumulated knowledge, was the greatest contribution to the advance of civilisation; but this was due to the engineers who built the presses, who cast the metal type and produced the paper.

Engineers owe much of their present skill to the work of scientists and the organisers or industrialists who have provided funds and suitable environment; indeed, the ever-accelerating machine of progress moves as an integrated whole, each part dependent on the others to sustain its momentum.

But first came the engineers; and so far as their contribution to the comfort and convenience of our everyday life is concerned, they still come first.

A New Power Boat Club

● NEWS HAS reached us that a model power boat club is being formed to cover the Southfields and Putney districts of South-West London. It is being called the "Kingsmere Model Power Boat Club," and its home water is the Kingsmere Pond, Wimbledon Common.

Owing to the fact that residents in a nearby block of flats have objected to the noise caused by large i.c.-engined hydroplanes, the club is unable to permit the running of engines of more than 5-c.c. capacity. But it has some boats powered by 2-c.c. c.i. engines which have attained 30 m.p.h., and one boat with a 2.5-c.c. c.i. engine which has, to date, done 36 m.p.h., though there are hopes that this may be improved upon.

Mr. F. Curtis, whose address is 20, Lainson Street, London, S.W.18, will be pleased if any interested reader will get into touch with him. Owners of racing boats up to 5 c.c. will be cordially welcomed; and so will anyone possessing "prototype" power boats, a nice fleet of which already exists.

Novel Use for Ploughing Engines

● MR. V. C. RICHARDS, hon. secretary of the Isle of Wight Model Engineering Society, has reported that when he was in Southampton a little while ago, he saw a pair of Fowler engines fitted with a wide-mouthed "bucket," or drag-line shoe, in place of the plough; they were busily engaged in dredging brick rubble and other blitz debris out of the harbour, between Royal Pier and the Docks. Surely, someone has taken a photograph of this? Or, is this distinctly novel use of ploughing engines to go without permanent record? It will probably never be seen again.

New Liveries, British Railways

● THE RAILWAY EXECUTIVE has, at last, issued a definite statement as to the future styles of painting for locomotives and coaches. For heavy-duty express passenger locomotives the colour will be blue, with black and white lining. Selected passenger locomotives will be painted dark green, with black and orange lining. Other passenger and mixed-traffic locomotives are to be black lined out with grey striping, cream and red lining. Freight locomotives will be black, without lining.

Main-line corridor coaches will be painted crimson lake with cream panels. Coaches for local steam services, and passenger train vans, crimson lake, while multiple-unit electric coaches are to be green.

In view of what has been seen, in the way of experimental liveries, on the railways since last June, the announcement contains two not entirely unpleasant surprises. Blue with *black and white* lining is to be preferred to the same colour with grey, cream and red lining as has appeared on all the "experimental" blue engines during the last seven months. That *selected* passenger locomotives (whatever that may mean) are to be painted dark green, with black and orange lining, suggests the retention of the *ex*-G.W.R. livery for certain types of engines; and that will give much pleasure to thousands of enthusiasts.

On the Western Region and, we think, on the Midland, as well, some coaches are already running in the crimson lake and cream panels; the general effect, curiously enough, is much less austere than the "plum and split milk" which has been publicised so often, just lately. The "lake and cream" is decidely warmer and more congenial.

The particular shade of green for the multiple-unit electric trains is not specified; but a few specimens we have noted indicate a brilliant colour not far removed from the *ex*-S.R. malachite. Taking everything into account, the future appearance of locomotives and coaches might have been far worse!

Two for One

● WE OFTEN publish announcements to the effect that some reader thinks that a model engineering club could be founded in his locality, and he invites other readers in his district to get into touch with him to discuss the matter. The usual result is that, eventually, we are able to publish the news that the proposed society has come into being.

It is not so often, however, that we hear of two societies being formed as the result of a proposal to establish one. One instance of this has just come to our notice from the far north of Scotland. About a year ago, we published a request from Mr. W. McDonald, of Thurso, that readers in that area should contact him with a view to forming a society. Among the replies he received was one from Mr. John Graham, of Wick, and the eventual outcome was that two societies were formed, one in Thurso and the other in Wick; both are now "going concerns."

In sending us this interesting item of news, Mr. Graham, who is chairman of the Wick society, states that both clubs have been able to secure accommodation and are in process of collecting tools, etc. for the benefit of all members. Substantial interest in the new ventures has been shown in both towns and, in particular, every effort is being made to encourage the younger members who are principally interested in model aircraft. Mr. Graham adds: "As these are the most northerly societies in the country, and far removed from sources of supply of materials for model engineering, it would be appreciated if suppliers could let each of the clubs have copies of their latest catalogues and a note of terms for supplies to clubs, for the benefit of the members."

In view of this request, we would add that Mr. McDonald's address is: Scrabster, Thurso, Caithness; Mr. Graham's is: Town House, Wick, Caithness.

The Bombay Society of Model Engineers

● A COPY of the sixth annual report of this society has just come to hand from Mr. M. P. Polson, the society's energetic and popular Chairman. The report shows that the society is in a sound financial condition, though the publication of the society's bulletin, suspended in October, 1947, is not yet resumed, owing to the cost involved.

A commendable scheme introduced during 1948 was the enrolment of thirty poor boys, five from each of the six well-known schools in Bombay; this idea is based on the desire to inculcate craft-training among the really deserving poor, and the thirty chosen boys enjoy all the facilities and privileges of membership free of any charge. The scheme should do much good by inducing an interest in the practical application of craftsmanship.

IN THE WORKSHOP

by "Duplex"

33—Additions to Machine Tools

(1) Simple Dividing Gear for the Myford ML7 Lathe

WHEN buying a small lathe, the amateur or professional worker naturally selects one which will most nearly meet his requirements.

We say—most nearly — because there can be no such thing as the ideal lathe or one which, when sold at a moderate price, will suit all tastes or will be equipped for undertaking the wide range of machining operations of which the lathe is inherently capable.

From the manufacturer's point of view, any attempt to supply his standard productions with alterations, variations and special adaptations to satisfy the needs or whims of a minority of purchasers would, no doubt, lead to early insolvency.

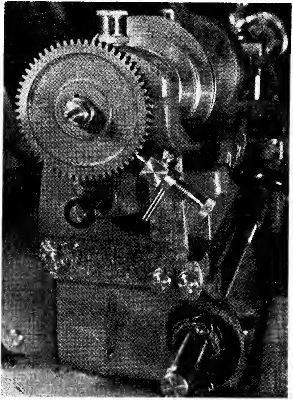


Photo by] [*P. G. Collier*
Fig. 1. Dividing from a single change wheel

Lathes can only be produced at a price within the reach of the ordinary user by adhering to a standard design, and adopting efficient manufacturing methods which maintain both the quality and quantity of the output.

As has been so often advocated by those of wide practical experience, the most suitable type of lathe for the great majority of workers is one of relatively simple design, but of really sound construction combined with accurate workmanship. A tool such as this will meet the requirements of many workers and, moreover, they can at any time further equip the lathe, should they so desire, with the special attachments supplied by the makers for carrying out more elaborate machining operations, such, for example, as dividing, gear-cutting and taper-turning.

Besides these appliances for performing major machining operations, there are minor but important additions which will be found to contribute greatly to the convenience of operating the lathe in the course of ordinary working.

Manufacturers, however, very rightly concentrate on producing a sound and reliable tool at a moderate price rather than offering a lot of detail work and fittings at the expense of the major requirements of good workmanship in the essential parts. There are, moreover, many workers who are not only capable of developing their lathes in this way but who derive great pleasure in carrying out the necessary work, thereby possibly reducing their initial monetary outlay and certainly increasing the utility of the machine.

It is with this in mind that we venture to describe some of the additions that have been made to our own lathes and machine tools, and to those belonging to friends who have sought our advice on this subject. In point of fact, a skilled and experienced fellow worker, who had all too little time to devote to his hobby, recently brought his ML7 lathe to us with the request that we should embellish it as we thought fit, bearing in mind that this lathe is equipped with the full range of attachments and is used for a great variety of work.

It is, therefore, the additions made to this lathe that it is proposed to describe in the first place, but at the same time it should be borne in mind that much of the work is equally applicable to lathes in general, and many of the fittings have been used in connection with lathes of other types.

When making alterations and additions to machine tools, it has always been an important consideration with us that in no case should the general structure of the machine be interfered with in any way, nor even should holes be drilled in any of the main parts if this can be avoided ; if this plan is adhered to the machine is not made non-standard, and at any time it can be returned to its exact original form should the alterations not find favour or its disposal be contemplated.

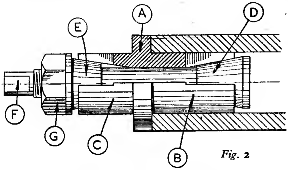


Fig. 2

Simple Dividing Gear

As distinct from dividing by means of a special dividing-head, dividing from a single lathe change wheel, or from a train of wheels, will cover most of the work of the kind usually undertaken in the small general workshop. In the present instance, a form of simple dividing gear will be essential for making some of the additions that are to be described.

Dividing from a Mandrel Wheel.

If any of the lathe change wheels is securely fixed to the tail end of the mandrel and a rigidly-mounted detent is used to engage the tooth spaces, then by making use of the whole series of wheels a wide range of divisions, particularly in the lower numbers can be obtained.

Thus, any number of divisions from one to fifteen and also their lower multiples become available, whilst if care is taken the accuracy of the work produced will be comparable with that of the wheel itself. Further, this arrangement, which is illustrated in Fig. 1, will also serve as a useful lock for the mandrel.

It is, of course, essential that the change wheel so used should be firmly secured to the mandrel so that there is no possibility of its shifting its position during the dividing operation, and at the same time it must be mounted to run truly.

The method adopted for fitting the wheel is that illustrated in the general arrangement drawing, Fig. 2 ; this shows a two-ended adaptor *A* is used, one end, *B*, fitting into the mandrel bore and the other, *C*, carrying the change wheel. Both ends of the adaptor are split and are expanded when the internal cones *D* and *E* are drawn together by tightening the nut *G* fitted to the central bolt *F*. As these cones have only a moderate degree of taper, they exercise a powerful radial thrust, and in practice it will be found that relatively light tightening pressure applied to the draw-nut will be sufficient to lock the parts securely in place.

Construction

In the first place, the mandrel bore should be examined, and if the tooling marks are prominent it is advisable, but not essential, to employ an adjustable reamer to establish a smooth surface finish.

The body of the adaptor, *A*, is made from a length of 1 in. diameter mild-steel bar which is gripped in the chuck and then faced and bored

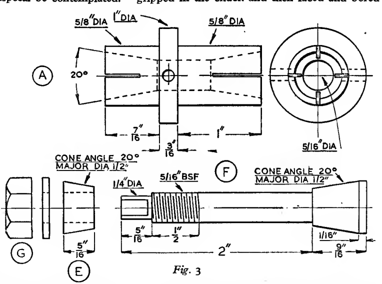


Fig. 3

for its full length with a $\frac{5}{16}$-in. clearing size hole. The top slide is next set over to 10 deg., and the tapered portion of the bore at the end *B* which enters the mandrel bore is formed with a small boring tool in accordance with the working drawing shown in Fig. 3.

When a cut has been taken to true the surface of the projecting part of the work, the external diameter is reduced to make the portion *B* a

good push fit in the lathe mandrel. The work is then reversed and set to run truly in the four-jaw chuck so that the other end *C* of the adaptor can be taper bored internally, and then turned on its external diameter to fit closely into the bore of the change wheel.

The work is next removed from the lathe and

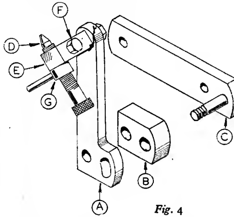


Fig. 4

gripped in the machine vice for drilling two diametrically opposite $\frac{1}{8}$ in. diameter holes in the collar. These holes are to accommodate two short tommy-bars for the purpose of gripping and removing the adaptor from the mandrel bore.

Finally, both ends of the adaptor are slit with a fine hacksaw, by making two cuts crossing at right-angles, to allow the metal to expand when the internal cones are closed on tightening the central bolt.

The expander bolt *F* is turned in accordance with the drawing from a length of $\frac{5}{8}$-in. diameter mild-steel rod supported by the tailstock centre. The coned portion *D* is formed by again setting over the top slide to 10 deg. but in the reverse direction. The correct mating of the internal and external cones should be checked by drawing a series of pencil lines along the male cone, and if the female cone is then applied with a twisting motion, the lines should be evenly obliterated where the fit is correct; should the pencil marks indicate that proper contact is not being made, the top slide must be reset to correct the error.

After the thread has been formed by means of a $\frac{5}{16}$-in. B.S.F. die guided by the tailstock the bolt is parted off to length and two small flats are filed or machined at its outer end.

The purpose of the flats is to afford a hold for a spanner in the unlikely event of the bolt itself rotating when the clamping-nut is turned; if no trouble of this sort is experienced, the end of the bolt can be shortened at a later stage for the sake of appearance.

The small movable cone *E* is turned as in the previous instance, and is then bored to a sliding fit on the shank of the clamp-bolt.

To complete the adaptor, a $\frac{5}{16}$-in. B.S.F. nut *G* and washer are fitted to the end of the bolt. When the parts have been assembled, a change wheel is mounted in place and the adaptor is pushed into the mandrel bore; the clamp-nut is then tightened to secure the parts in position. The adaptor is removed by slackening the clamp-nut a single turn and then tapping the end of the clamp-bolt inwards to free the internal cone.

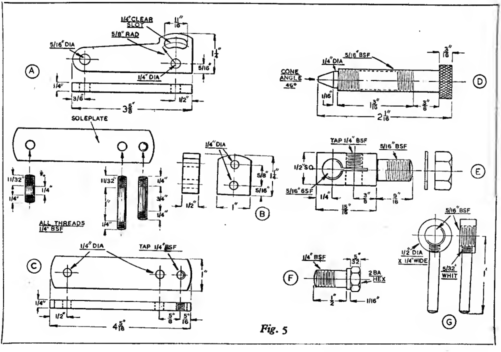


Fig. 5

Where the adaptor has been made a good fit in the mandrel, the two tommy-bars previously mentioned will have to be used to remove the adaptor by applying a twisting motion.

The Mandrel Wheel Detent

To enable the change wheel to be used for indexing when it is attached to the mandrel by means of its adaptor, it is necessary to fit a rigid form of detent that will engage the spaces between the teeth.

The detent shown in Figs. 1 and 4 is secured to the end of the lathe bed by means of studs set in the tapped holes provided for attaching the back cover of the standard wheel guard.

If desired, the cover plate can be retained, but the drawings relate to a detent fitted after this plate has been removed.

In this connection, it will be noted that formerly small lathes designed mainly for amateur use were, as a rule, fitted with guards to the back gear, but the belts and change wheels were not protected in any way. This is understandable, as the amateur worker usually prefers that all parts of the lathe should be readily accessible, and at the same time he generally has the foresight to avoid risking an accident; but now that lathes of this type are used commercially, or can be readily adapted for this purpose, the manufacturers meet the situation by supplying, as part of the standard equipment, the necessary safeguards prescribed by the Factory Acts.

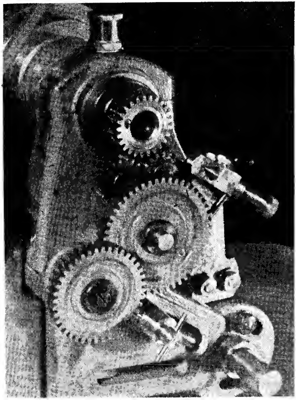


Photo by] [*P. G. Collier*
Fig. 6. Dividing from a train of wheels

The actual making of the attachment is quite straightforward and calls for little explanation, for the general arrangement of the components is shown in Fig. 4, and the detailed dimensions of the several parts are given in the working drawings in Fig. 5.

Before fitting the soleplate *C*, it is advisable to pass a file across the end of the lathe bed to remove any irregularities adjacent to the stud holes; a washer is then fitted to each of the two long studs so as to provide an even bearing surface for the plate. To ensure that the parts, *A*, *B* and *C* can be assembled correctly, it is advisable first to drill a single hole in each part and then to drill the second hole right through all the components after they have been bolted together.

It will be seen that the outer bolt-hole in the base of the pillar is slotted; this allows the pillar to be set so that the point of the detent *D* does not project unduly beyond its supporting bracket *E*, when the change wheels of either large or small diameter are in use. The point of the detent should be turned to fit the wheel tooth space, and, if the coned tip is machined to an included angle of 46 deg., it will mate with the 60-tooth wheel, which is the size most generally employed for simple dividing operations.

It will also be observed that the bracket *E* is split so that the fit of the thread can be adjusted as required, by means of the clamp-screw *F*.

When the detent is used either for dividing or for locking the lathe mandrel, it is secured by tightening the handled lock-nut *G*, after the point has been carefully engaged in the required tooth space to eliminate all backlash.

Dividing from the Quadrant Change Wheels

As was previously stated, when dividing from a change wheel correctly mounted on the mandrel, the accuracy of the work produced will be comparable with that of the wheel itself. Where a train of wheels is employed, however, additional errors are introduced, for example, by the presence of the wheel bearings and by the spring in the wheel mountings. Moreover, it is far from easy to mesh all the wheels in the train exactly on their pitch-lines in order to ensure regularity of the turning movement from wheel to wheel.

Cutting gear wheels accurately to pitch can, therefore, hardly be expected when this method is employed, but less exacting dividing operations can be carried out quite satisfactorily in this way.

One advantage of using a wheel train is that division into a large number of spaces is possible, whereas with a wheel mounted on the mandrel,

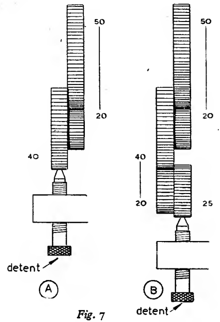


Fig. 7

the number of divisions obtainable is limited by the size of the largest change wheel available.

The method of dividing from change wheels mounted on the quadrant is illustrated in Fig. 6 which shows the arrangement of the wheel train and detent used for indexing the work into 100 divisions. It would, of course, be preferable to mount a 100-tooth wheel directly on the mandrel, but as a wheel of this size is not included in the standard set of change wheels, the alternative method must be adopted.

It will be clear from the drawing in Fig. 7 (A) that a reduction gear of 2 : 1 is employed to obtain 100 division from the 50-tooth wheel. Fig. 7 (B) shows how a compound wheel train can be set up to provide for dividing into 125, as when making an index for a feedscrew of $\frac{1}{8}$ in. pitch. An alternative method of dividing into 125 is to connect a 75-tooth wheel with the mandrel and to obtain a reduction of 5 : 3 by gearing with it a 30-tooth wheel coupled on the same stud to a 50-tooth wheel for meshing with the detent. The set-up is then like that shown in Fig. 7 (A), except, of course, that wheels of different size are employed.

The Detent

The general appearance of the detent used in this instance is shown in Fig. 6, and the constructional details and dimensions are given in Fig. 8.

Where the detent is used only in connection with the wheel arrangement shown in Fig. 7 (A), that is to say, contact is made with the outer of the two wheels mounted on the stud, then the form illustrated in Fig. 8 (A) will be appropriate; but when indexing from a wheel mounted on the inner end of the stud, as in Fig. 7 (B), a detent with less stand-off is required.

The detent depicted in Fig. 8 (B) has, however, a removable distance-piece so that it can be used with either of the two types of wheel arrangement described.

As was pointed out in a previous article, it is

(*Continued on page* 348)

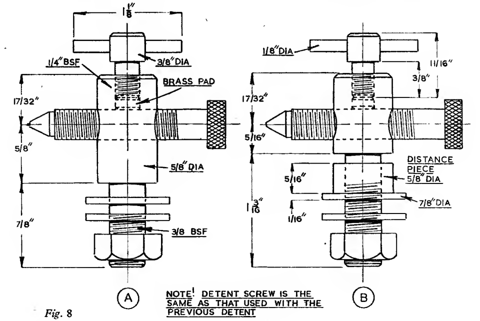
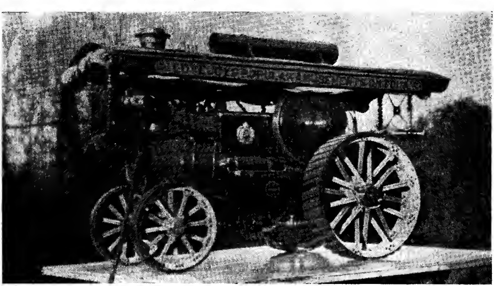


Fig. 8

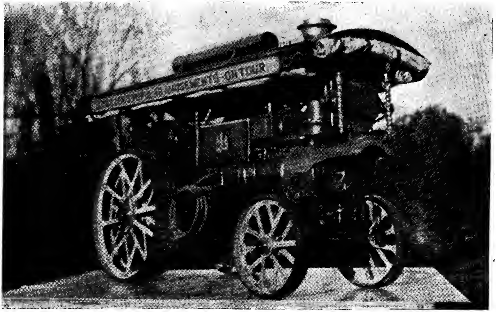


A Free-lance Showman's Engine

THE showman's engine seen in the photographs reproduced herewith has recently been built. It is a four-shaft, double-crank, three-speed, free-lance engine built to the scale of $1\frac{1}{2}$ in. to the foot. It operates as a stationary unit and is electrically driven by a belt.

The "dynamo" on the smokebox is, in fact, a *motor* filched from my wife's sewing-machine, and it serves to drive the top motion-work with realistic effect assisted by an electric light underneath the awning to illuminate the "works."

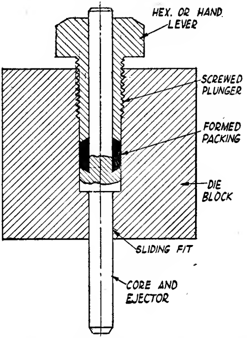
Unfortunately, in the photographs the motion-work is hidden by the side panels which, however, are readily detachable for showing off the model when it is in action.—H. S. Johnson, M.I.N.A.



*UTILITY STEAM ENGINES

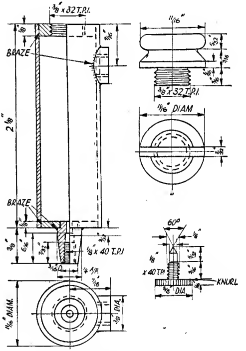
by Edgar T. Westbury

THE gland nuts for the piston-rods and slide-valve rods of the "Warrior" engine are all tapped ¼ in. by 40 t.p.i., and although different external forms of these glands are shown in the general arrangement drawings, it has been considered desirable to make them of uniform shape and size, with the exception, of course, of the hole for the rod, which should be an easy sliding fit in each case. Care must be taken to drill and tap the gland nut so that the threads and the bore of the mouth are concentric, and assuming that the external threads of the lower cylinder covers and the steam chests have been made with equal care, this should ensure that the gland nuts will not bind on the rods in any position. Inaccuracy in either the threads or the central holes will necessitate opening out the mouths of the gland nuts to a sloppy fit, with the result that the gland packing will tend to be squeezed out and will never bed down properly to the rods, with consequent leakage of steam and perpetual gland trouble.



A simple die for making pre-formed packing rings (twice full-size)

The slots on the outside of the gland nuts can be "planed" while still set up in the lathe, before parting the nuts off. Most readers know how to do this, but in case the method is unfamiliar, it may be advisable to give a brief explanation. A narrow but fairly stiff parting tool may be used for this operation; it is held on its side in the tool-post, at right-angles to the lathe axis and with the cutting edge exactly at centre height.



Details of displacement lubricator

With the lathe spindle stationary, the tool is traversed backwards and forwards across the nut by the rack or the slide-rest screw, feeding in very slightly by the cross-slide at each pass until the required depth of slot is produced. Greedy cuts must be avoided, as they will only result in digging in or shifting of the tool. Some means of indexing the lathe mandrel, to produce the required number of slots, will be necessary, but this need not be elaborate; scribed marks on the edge of the chuck backplate, in conjunction with a jury-rigged index pointer, will serve the purpose quite well. Four slots are shown in the drawing, but six or eight will be better still, especially for the piston-rod glands, which are somewhat inaccessible when the engine is assembled. It will be advisable to make a little C-spanner to engage the slots in the gland nuts.

A word on the subject of gland packings may

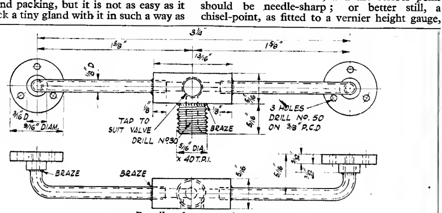
**Continued from page 280, "M.E.," March 10, 1949.*

not be out of place at this stage. The amount of room allowable in a small packing gland is rather inadequate, and the obvious remedy of making the gland considerably oversize is often impracticable without upsetting the whole engine design. Graphited yarn is an excellent form of gland packing, but it is not as easy as it looks to pack a tiny gland with it in such a way as to produce an even pressure all round the rod. In my experience, pre-formed packing rings are the best solution to the problem, and are not at all difficult to make in a small die filled with a screwed plunger for compressing the packing material. The bore of the die should be 7/32 in. diameter, with a central pin equal in diameter to the piston-rod or valve-rod, which may also be combined with an ejector for removing the finished ring.

Shredded asbestos, obtained by pulling to pieces the fibres of asbestos string or millboard, is packed into the die, together with a little graphite grease (or a mixture of flake graphite and vaseline), and rammed down hard with the plunger; the amount of packing required to produce a ring of the desired thickness can soon be found by experience. The rings are solid enough to stand normal handling when formed in this way, and the disadvantage of having to dismantle the crosshead or valve-rod fork to fit them is offset by the long working life, and freedom from squeezing out or jamming of the packing in the gland threads.

Assembly

The bedplate of the engine should be carefully marked out, by clamping to an angle-plate and using a scribing block, first marking the longitudinal centre line and then, symmetrically on either side, the centre lines of the bolts for the main bearings and the feet of the trunk columns. Next the casting should be turned at right-angles on the angle-plate, the main centre line tested with a try-square, and cross lines marked to show the centre lines of these bolt holes. For such marking off operations, a height gauge will be found extremely useful, but if this is not available a steel rule mounted vertically on a simple stand, preferably with some form of height adjustment, will serve the purpose. It is advisable to start off by correlating the height of the work and the rule so that the main centre-line, or some other salient mark, represents an even figure on the rule, and measure all other locations from this point. Unless one is gifted with very sharp eyesight it will be found advisable to use a lens in setting out these measurements, and the scriber point should be needle-sharp; or better still, a chisel-point, as fitted to a vernier height gauge, may be used. From some experience in marking out small work, I consider that this fundamental operation requires the best skill and care one can put into it. Slipshod marking with a blunt scriber often results in the ruination of accuracy, and all the precision work in machining parts to micrometer measurements being literally wasted.

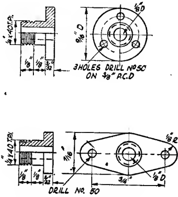


Details of steam pipe

As the split main bearings have already been drilled for the securing bolts, it will be necessary to relate their bolt holes in the bedplate so as to take into account any possible inaccuracy in the holes in the bearings. The most important point to be considered here is the true alignment of the shaft, and the best way to do this is to use a piece of dead straight ½ in. steel rod. Lay the lower halves of the bearings in their respective positions (make certain when removing the top halves that they are marked so that they can be replaced in correct order, and the right way round) and arrange clamps on the rod so that the bearings can be held down firmly. The marked cross lines on the bedplate bearing seatings should now coincide with the bolt holes in the bearings themselves, but if not, a compromise must be effected so as to get them as close as possible, while preserving true shaft alignment. Then the holes can be spotted through from the bearings on to the bedplate, and drilled for the holding down bolts or studs.

It has already been mentioned that tapped holes in the lower halves of the bearings are recommended so that they can be secured to the bedplate by set screws from the underside, projecting far enough to enable the upper halves (which have clearance holes) to be held down by nuts. This differs from the orthodox procedure of fitting studs to tapped holes in the bedplate, but is considered better in the particular circumstances, as once the lower halves are fixed in position (using the aligning rod as when locating the holes) they cannot be disturbed when the caps are lifted at any time.

The location of the trunk columns may be carried out in a somewhat similar manner, but any minor errors in location will not affect mechanical alignments, providing that the machining is carried out as described; they may, however, affect the appearance and symmetry of the engine, and are worthy of attention from that aspect. It will be noted that countersunk screws are used to secure the lower cylinder cover to the



Steam and exhaust pipe stub flanges

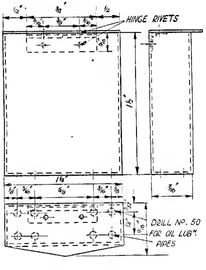
cylinder block, and the heads of these must either be well sunk or machined off after fitting, so that they do not interfere with the proper seating of the cover on the top flange of the column. Locate the cylinder block so that the valve chest face is square with the plane of the shaft axis, and spot the corner holes in the lower cover through into the column flange to take either bolts or set screws.

After the crankshaft has been fitted to the main bearings and bedded in to run freely, the connecting rods may be fitted and their alignment with the crosshead checked up. If any side binding of the crosshead bearing is detected, the reason for it should be found and corrected. It may be that the centre line of the column is not symmetrical with the centre of the crankpin bearing, or that the web of the crosshead is not truly central. Do not bend or strain the rod to correct such discrepancies; it is better to allow side play in the crank or crosshead bearings, or both, to avoid the risk of binding, but do not do this unnecessarily. In some cases, machining the cheeks of the main bearing may be found desirable to allow of endwise adjustment, but in such cases final location should be made, by suitably setting the eccentric sheaves, to prevent any more than a trace of end movement. The wrist pins in both the crosshead and valve rod fork may be in the form of plain pieces of steel rod made to a press fit in the outer members, and may with advantage be case-hardened.

In order to screw the piston rod into the top of the crosshead, a slot may be sawn across the piston crown, preferably with a small circular saw, so that it does not cut into the outer edges. If the thread of the piston rod is on the tight side, as recommended, no further securing is necessary, but there is room to fit a small lock-nut over the top of the crosshead if desired. Adjust the position of the piston so that top and bottom clearances are exactly equal. Before final assembly, the groove of the piston is packed with graphited packing in the usual way.

Valve setting on the "Warrior" engine follows orthodox procedure, as described for the "Trojan" engine; namely, first set the position of the valve, by adjusting the nut on the rod, so that the ports open the same amount at the top and bottom of the eccentric stroke. This setting can of course be done with the steam chest cover removed, so that the valve is visible. Then set the eccentric sheave so that when the crank is exactly at top dead centre, the top steam port is just commencing to open. As the eccentric is fixed in this case, the engine is not reversible under running conditions, but may be set for either direction of rotation. It is, however, possible to fit slip eccentrics, as in the "Trojan" engine, or if desired, link reversing motion may be added. When the engine has been tried under air or steam, and the constructor is satisfied that the valve setting is satisfactory, it is advisable to fix the eccentric sheaves firmly by sinking the points of the grub screws in "dimples" drilled in the shaft.

Other fittings for the engine include the steam and exhaust pipes, the displacement lubricator, and the oil box, all of which may be varied in design to suit the taste or requirements of the constructor, or the form of installation. A



Details of oil box

suitable steam distribution pipe, with circular flanges for attachment to stub flanges screwed into the steam chests, is illustrated. The exhaust pipe shown in the photograph, and in the general arrangement drawing, has oval flanges, but may be made uniform with the steam pipe if desired; the branched pipe shown is also optional. Flange joints are recommended for an engine of this type, being more truly representa-

tive of full-size practice than union joints, though the latter are quite satisfactory from the practical aspect if properly made, and in certain circumstances, are easier to manipulate in cramped spaces.

The displacement lubricator is of orthodox type, but of rather greater capacity than most of those fitted to small engines. It is built up by silver-soldering, but may be partially or entirely made from the solid if preferred. It connects directly into the main steam distribution pipe and is not fitted with an isolating valve, as it is rarely necessary to refill it while under steam, but this refinement may be added if desired.

Few small steam engines are fitted with really adequate arrangments for oiling the bearing, and in this respect the fitting of a large capacity oil box to the engine is a real advantage. The box may be built up from copper sheet by silver-soldering, and the hinge may be of the ready-made type, riveted on, though it is not difficult to make one much neater and more appropriate to the purpose from sheet copper. An angle bracket may be riveted to the back of the box for attaching it to the top of the trunk columns.

Distribution pipes are taken from the box to the trunk crossheads, and to drip pipes over the cranks; further pipes to supply the main and eccentric strap bearings would be useful. The pipes are $\frac{1}{16}$ in. diameter and may be fitted with dummy unions, as real ones would be very delicate to machine and fit. They are carried up inside the box to within $\frac{1}{4}$ in. of the top, and fitted with wicks made from cotton or hemp fibres, obtained by unravelling the strands of soft twine or textile fabric. A short length of fine wire, twisted into an eye at one end, is used for inserting the wick in the pipe, after which it is bent over the top of the pipe and left in position.

Although not specified in the detailed drawings, some form of lagging or "cleading" on the cylinder blocks is desirable not only for the purposes of conserving heat as much as possible, but also to improve the appearance of the engine. The usual form of lagging on these small engines consists of a thin blued iron plate enclosing insulating packing, such as shredded asbestos or slag wool. If desired, the two cylinders may be enclosed in a single casing of this type to give the impression of being made in a solid block, in which case it will be necessary to fit a suitably shaped piece of sheet metal between the two cylinder covers to enclose the top of the lagging. In the event of the blued steel or "Russian" iron generally used for this purpose not being available, it is quite a simple matter to colour a piece of thin sheet steel by heating it in a sand bath until the required colour is obtained. If the metal is clean and bright, it will take on a brilliant blue or purple colour, which may be considered too vivid, but by coating the surface with oil before heating, a brownish colour will be obtained. An alternative to the sheet steel lagging, which further improves the appearance, is to use teak or mahogany staves held in place by two brass bands on each cylinder block.

The bed-plate of the engine incorporates a seating for the purpose of fitting a feed pump on the engine, and this may be either direct driven or geared as shown in the photograph in the February 10th issue. If the engine is to be run at a fairly slow speed, a direct driven pump is preferable, but for high speed engines, reducing the speed in the ratio of 3 or 4 to 1 is advisable. A ready-made pump of the type obtainable from Messrs. Stuart Turner or Bassett-Lowke will serve the purpose quite well.

(To be continued)

In the Workshop

(Continued from page 343)

essential, when employing wheel trains for dividing, to take up the backlash in one direction and to maintain the gears in this position during the actual tooling operation on the work.

As mentioned earlier, any spring present in the wheel mountings may, amongst other things, cause inaccuracy; so keep this source of error as far as possible constant, it is essential to apply a constant pressure when eliminating the backlash.

Hand pressure, which is variable, should not, therefore, be used for this purpose, and, instead, a suspended weight should be employed to maintain a constant pressure. Although the practical application of this method has been described on a previous occasion, it may not be out of place, briefly, to recapitulate. The chuck key is inserted in one of its slots, and a loop formed at the end of a length of cord is passed over the key; the cord is then given a couple of turns round the body of the chuck, whence it passes over the edge of the bench and has a weight attached to its free end.

The mass of the weight need not be great, but it must be sufficient to counteract any turning movement imposed on the work by the machining operation. When engaging the detent in a tooth space, the pressure exerted by the weight should be relieved by steadying the chuck key with the hand, so that the point of the detent can enter unobstructed to its full depth.

Where change wheels, attached either to the lathe mandrel or to the quadrant, are employed for dividing, it may save making errors and spoiling work if at the outset the tooth spaces required are clearly marked with chalk or by means of a grease pencil.

Marking-out the teeth in this way will be greatly facilitated, and errors will be avoided, if the dividers are set to the interval required and are then used to step out the circumference of the wheel.

(To be continued)

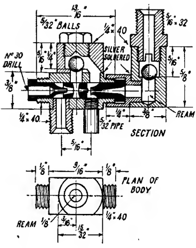
Injectors for "Maid" "Minx" and "Doris"

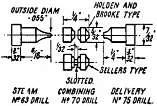
by "L.B.S.C."

THE same size and type of injector will do for all three engines. It is practically the same as I have previously described for the "Lassie," "Petrolea" and other engines, and is the result of considerable experimenting, in the days gone by. I have personally made and tested out other types of injectors, such as the combination type, ordinary vertical, Gresham and Craven with sliding cone, Penberthy with flap valves, and so on, and got them all to work; but the "Vic" type shown here is the simplest of the lot, and so will appeal to beginners. If made exactly to given dimensions, it will start easily, restart if accidentally "knocked off" by the jarring of the engine, or water swishing about in the tender; will take feedwater up to 120 deg., and most important of all, it takes very little steam to operate. It will not "knock the steam-gauge sick," as the enginemen say, if operated whilst the engine is running; up to time of writing, I have not heard of any commercially-made injector for which the same claim can truthfully be made. It will work right from blowing-off point, until there isn't enough steam to blow the whistle, and will start at 30 to 35 lb. Regulation of the water-valve on the tender will prevent the overflow dribbling at low pressure. The injector is 100 per cent. reliable, *as long as it is kept clean*; full-sized injectors frequently fail through dirty and furred-up cones, and with the tiny holes in the cones of the small one, the veriest Billy Muggins will appreciate the necessity for thorough cleaning.

Beginners Please Note—

Before going into details, may I offer a word of advice, especially to beginners. As stated above, if made exactly to instructions, the injector will work perfectly. If it fails, then either it is *not* made to the given dimensions, or else there is an external fault; maybe in the pipes, steam-valve or delivery clack. It isn't the slightest use writing in and telling me that you made it as stated, and it won't work; I've heard that tale too many times before! Only a few weeks ago, a reader, without as much as by-your-leave, flung his failure at my devoted head, in a manner of speaking, with a request to try it, as "it was made to instructions and wouldn't work." I had no need to try it; one glance was enough! There was over 1/16-in. gap between combining and delivery cone, which was sufficient to prevent it feeding; but from curiosity, I checked over the rest. The steam cone was two drill sizes too small, the taper in the combining cone far too steep, the delivery cone *nine* drill sizes too large! ("made to instruction"—I ask you) and the air release-valve leaking. If the maker had taken the trouble to check over the gadget, he would have saved both his own time and mine. Incidentally, I never even received a "thank you" for telling him why it failed. 'Nuff sed!





Details of injector

If your injector fails, when perfectly clean, on first trial, check over every detail; and if you are absolutely and positively certain that the gadget itself is O.K., then look for the following. Steam-valve not letting enough steam pass; steam pipe too small in bore; water going over with the steam; hose connection between engine and tender kinked, or some other obstruction in feed; air being drawn in with the water; too sharp a bend, or other obstruction in delivery-pipe; top clack not lifting freely. An injector clack needs more lift than a pump clack. One injector I tested for a friend, failed because he left a weeny air-hole when silver-soldering in the water nipple. So much for that; well, let's get to business.

Cone Reamers

Before starting operations, make your cone reamers. Three pieces of 5/32-in. round silver-steel are needed, about 2 to 2½ in. long. Chuck one in the three-jaw, and turn a taper on it ¾ in. long. Ditto repeato on the second bit, only

this time make the taper $1\frac{1}{4}$ in. long. No. 3 only needs a little stubby point $\frac{3}{16}$ in. long, but it isn't a straight taper; radius it a little as shown in the illustration. If you use a round-nose tool with plenty of top rake, run at a good speed, take light cuts, and use plenty of cutting oil, you'll get clean tapers and no chattering. The radius of the tool doesn't have to be too big; more like a pointed tool with the point rounded off (says Pat). Don't have more of the rod projecting from the chuck than is absolutely necessary.

The rest of the job is exactly the same as described for the drain cock reamer a little while back. File away to half the diameter, harden and temper to dark yellow, and oilstone up the flats. A stop is needed, to prevent the reamer going in too far; this is merely a 1-in. length of $\frac{5}{16}$-in. brass rod, drilled No. 21 and fitted with a 3/32-in. or 7-B.A. set-screw, as shown.

Injector Body

No castings are needed, the body being either cut from the solid, or built up, which is far and away the easiest method. Part off a piece of $\frac{3}{8}$-in. square brass rod $\frac{7}{8}$ in. long, and chuck it truly in the four-jaw. Turn down 5/32 in. of the end to $\frac{1}{4}$ in. diameter, and screw $\frac{1}{4}$ in. by 40; then face off 1/32 in., which gives a full thread right to the end. Most dies tear the first thread slightly when they "take hold." Centre, drill right through with the No. 24 drill, and ream 5/32 in. Reverse in chuck; if you slack No. 1 and 2 jaws, turn the metal end for end, and re-tighten the same two, to the same degree of tightness, the embryo injector body should run truly whilst you repeat the turning and screwing process on the other end. The overall length should now be $\frac{13}{16}$ in., with $\frac{9}{16}$ in. of "plain" between the shoulders.

In the middle of one of the sides, drill a $\frac{1}{8}$-in. hole. At $\frac{3}{16}$ in. farther along, drill a 7/64-in. hole. On the other side, opposite to the latter hole, and $\frac{1}{8}$ in. from the shoulder, drill a No. 30 hole and tap it 5/32 in. by 40. At $\frac{1}{8}$ in. from the other shoulder, drill a 5/32-in. hole, and in it fit a $\frac{1}{4}$-in. by 40 union nipple, as described for boiler fittings.

Chuck a piece of $\frac{1}{2}$-in. round brass rod, face the end, turn down about $\frac{3}{8}$ in. of it to 15/32 in. diameter, and part off a $\frac{5}{16}$-in. length. Scribe a line across the centre indicated by the tool marks; on this line, at $\frac{3}{16}$ in. from the side, make a centre-pop. Chuck in four-jaw with this pop running truly; open out with a centre-drill, drill right through with No. 34, further open out about 5/32 in. depth with 7/32-in. drill, bottom to $\frac{1}{4}$ in. depth with 7/32-in. D-bit, ream the remains of the small hole with a $\frac{1}{8}$-in. parallel reamer, and tap the enlarged part with $\frac{1}{4}$-in. by 40 tap for about $\frac{3}{16}$ in. down. Mind you don't damage the ball seating by running the tap in too far. On the same centre-line, starting from a centre-pop $\frac{3}{16}$ in. from the centre of the reamed hole, drill a No. 34 hole on the slant, to break into the ball-chamber about 1/32 in. or so above the ball seating; get as near to the seating as you can, without damaging it. File off any burrs, seat the fitting on top of the $\frac{3}{8}$-in. square part, so that the reamed hole lines up with the $\frac{1}{8}$-in. hole, and the slanting hole lines up with the 7/64-in. hole, as shown in the sectional illustration. Tie it in position with a bit of thin iron binding-wire, and silver-solder it, and the union nipple, at the same heating. Pickle, wash off and clean up; then poke the 5/32-in. reamer through the long hole again, in case there are any burrs. Seat a 5/32-in. ball on the hole, and make a cap from 5/32-in. hexagon rod, same as described for pumps. The ball should have about 1/32 in. lift as usual. The projecting sides of the ball-chamber can be filed flush with the injector body, or left as they are, just as you fancy. I usually mill mine off.

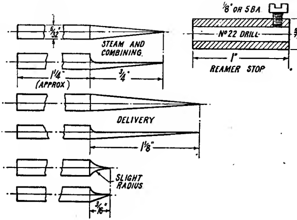
Cones or Nozzles

Now we come to what is usually the beginner's *pons asinorum*, and yet it needn't be anything of the kind, *if* they will only remember that when I write "drill 75," for example, I mean *exactly that*, and not about ten drill sizes larger. A big injector becomes a bit finicky about two or three thousandths off correct diameter in the throat of the delivery-cone; so you can bet your last dollar—if you have one—that these weeny gadgets *must* be about right. If O.K., they will do the job; if not, they take an unholy delight in putting water on the ground instead of in the boiler. Believe me, it is just as easy to get them right, as to make a mess of the whole doings; all you need is just ordinary care, and there is no difficulty.

Start with the combining-cone. Chuck a bit of $\frac{3}{16}$-in. rod, and turn down about $\frac{3}{8}$ in. of it to a tight squeeze fit in the 5/32-in. reamed hole. Now there's another point: I've seen injectors with the combining-cone soldered in, all because the cone was turned too small; and yet it is *so easy* to get a squeeze fit. Simply put a taper broach in the end of the injector body (the union end) and broach it the tiniest bit; just take out a mere scrape. Now if you turn the embryo cone so that it will just enter the broached end, 1/64 in. or less, it will be a proper squeeze fit in the reamed part. Simple, isn't it—like everything else when you know how! Face the end, centre, and drill $\frac{5}{16}$ in. deep with No. 72 drill first. An ordinary centre-drill isn't any use for centring the cones, as it makes too large a hole. I made a couple of centre-drills for the job, from two broken dental burrs; the broken ends were little more than 1/64 in. across, and they were just hand-ground to arrow points on a hard India oilstone. A cone point can be turned on a piece of $\frac{1}{8}$-in. silver-steel, a little over $\frac{3}{16}$ in. long. Harden and temper to dark yellow, then grind the extreme tip flat on either side, simply by rubbing on the oilstone. Very slightly back off each side of the arrow, and you have "the tool for the job." Beginners note—to drill a deep hole without breaking the drill, keep it clear of chippings; the cause of a disaster in 99 cases out of 100 is the flutes becoming choked with chippings and causing the drill to seize in the hole. I use a watchmaker's pin-chuck to hold the drill; this is held in a larger chuck, and a lever tailstock used, the sliding barrel being worked back and forth just like a pump ram, entering the drill about 1/32 in. at each stroke. As the drill comes out of the hole at each bite the

fragments of metal fall from the flutes, and there is no risk of seizure and breakage.

Haven't a lever tailstock, you say? Well, that doesn't matter. You must use the watchmaker's pin-chuck (they used to cost about ninepence each in Clerkenwell umpteen years ago) or failing that, solder the shank of the little drill in a bit of $\frac{3}{16}$-in. brass rod. Put a tap-wrench on the shank of the chuck, or the bit of rod, as the case may be; hold it in the tailstock chuck, with



Cone reamers and stop

the jaws tightened up just sufficiently to allow it to slide, and feed the drill into the brass rod by sliding it back and forth. Run the lathe at the highest possible speed without causing an earthquake, and you'll get a clean hole. After drilling with the No. 72 drill repeat operation with No. 70, letting it penetrate about $\frac{1}{16}$ in. at each go, and the result will be a hole of the right size. Cut back the nose slightly as shown in the illustrations, and part off at ¼ in. from the end.

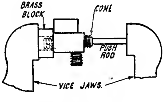
Reverse in chuck; put the reamer stop on the reamer with ¾-in. taper, letting the business-end project through ¼ in., plus 1/32 in., then put it in the tailstock chuck and ream out the cone until the stop comes up against the end, and the point is showing 1/32 in. beyond the nozzle end. Test for size; a No. 70 drill should pass through, and a No. 69 shouldn't. If you get that result, the cone is O.K. Radius the end slightly with the short stubby reamer.

Two types of combining cone are shown; the completely divided Holden and Brooke type and the slotted Sellers type, the latter being used in American injectors of that make. For the H. and B., put the cone in the three-jaw, letting it project a shade over half its length (nozzle end outwards) and saw it across with a jeweller's hacksaw. Pull out the bit left in the chuck a shade farther; face off the saw marks, and form a nose on the end, similar to the one first made. Re-chuck the other bit, sawn end outwards, and be sure it runs truly. Repeat facing and cutting-back operation, and give it just one touch with the stubby reamer, to remove the sharp edge around the hole.

To make a Sellers cone, form a $\frac{1}{16}$-in. groove 1/32 in. deep in the centre of it, using a parting tool; this should be done before parting it off the rod. Then file a couple of slots across the bottom of the groove, as shown in the illustration. Run the reamer in again, with your fingers, to clean off any burring inside the cone.

A Tight Squeeze

The cone can be squeezed in by using the bench vice as a press. You will need a small block of brass with a 17/64-in. hole in it, to go over the screwed end of the body, and rest against one vice jaw. A piece of ⅛-in. brass rod truly faced at the ends acts as a pusher. The set-up for pressing is shown in the illustration, which explains better than words. Turn the vice handle



How to press in combining cone

steadily until the first half of an H. and B. cone is 1/64 in. past the centre of the hole at bottom of ball-chamber. Then press in the second half until within 1/32 in. of the first. If you put a ⅛-in. strip of 22-gauge brass down the hole, after pressing in the first half, you won't get the second half too far in. A Sellers cone is pressed in until the $\frac{1}{16}$-in. groove is mid-way across the hole.

Steam Cone

Chuck a piece of 7/32-in. brass rod, and turn down $\frac{5}{16}$ in. length to a tight push fit in the injector body; then turn 5/32 in. of it to a nozzle shape as shown, *not* a blunt cone. The diameter at 1/32 in. from the end should be 0.055 in. or a bare $\frac{1}{16}$ in., and the end almost parallel. The shape is of great importance. Centre, and drill with No. 65 drill, then put the end of the ¾-in. taper reamer in until the nozzle is reduced almost to a knife-edge. Part off at 3/32 in. from shoulder, reverse in chuck, and drill No. 30 for a bare ¼ in. depth. Ream the bottom of the hole very slightly with the ¾-in. taper reamer until, when you put a No. 63 drill in by hand, it won't pass through, but you can just see it by looking down the nozzle. Then re-chuck, back outwards, and put the No. 63 drill through. The steam cone should enter the combining cone just 1/32 in.

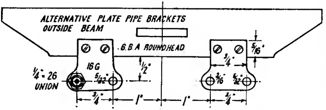
Delivery Cone

Chuck the 7/32-in. rod again, turn down ¼ in. length to a tight fit in injector body, then turn outside to shape shown. Centre, and drill down ⅜ in. depth with No. 77 drill; radius the end

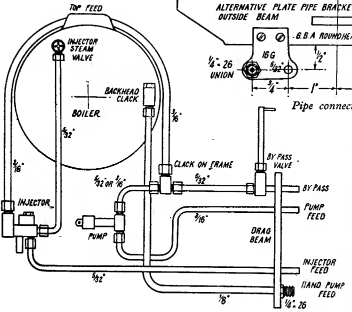
with the stubby reamer until it is a shade over $\frac{1}{16}$ in. across. Part off at 3/32 in. from shoulder. Reverse in chuck, and ream out with the $1\frac{1}{8}$-in. taper reamer until you can just see the point of it sticking through the hole at the bottom of the radius. Try a No. 75 drill in; if you can't push it through, but can just see the point, the hole is reamed correctly, to the right depth. Re-chuck the cone with the flange outward; put the No. 75 drill through (it won't need much pushing!) and radius out the end of the hole, with the stubby reamer, until about $\frac{1}{8}$ in. across, as shown in section. Assemble the cones as shown, put a bit of 5/32-in. pipe in the overflow hole, and there is your little squirt, all-present-and-correct-sergeant. Terribly difficult job making injectors, don't you think?

Delivery Valve

Chuck a bit of $\frac{3}{8}$-in. round rod in three-jaw. Face, centre, drill down $\frac{9}{16}$ in. depth with No. 34 drill, open out and bottom to $\frac{5}{16}$ in. depth with a 7/32-in. drill and D-bit, ream the remains of the 34 hole with $\frac{1}{8}$-in. parallel reamer, and tap the larger one $\frac{1}{4}$ in. by 40. Part off at $\frac{5}{8}$ in. from the end. At 5/32 in. from the bottom, drill a $\frac{3}{16}$-in. hole. Chuck a bit of $\frac{5}{16}$-in. rod, face, centre, drill down about $\frac{7}{16}$ in. depth with No. 30 drill, open out and bottom with 7/32-in. drill and D-bit to $\frac{3}{16}$ in. full depth, tap $\frac{1}{4}$ in. by 40, and part off at a bare $\frac{3}{8}$ in. from the end. Reverse in chuck, and turn down 3/32 in. of the end to a tight fit in the $\frac{3}{16}$-in. hole in the side of the valve body. Squeeze it in and silver-solder it. Fit a 5/32-in. ball and cap, same as described for the pump; make the union screw $\frac{5}{16}$ in. by 32, as we are using a $\frac{3}{16}$-in. delivery pipe to "Doris's" top-feed fitting. Screw the fitting on to the delivery end of the injector, so that it stands vertical. If it doesn't come right, just take a weeny skim off the flange of the delivery cone, until it does; don't wrench it and strip the thread. As the complete gadget only weighs about an ounce, the pipes are quite capable of sustaining its weight without any assistance; and when installed by the left-hand step on the engine, it is the work of a few seconds only to unscrew three unions (steam, water and delivery) and remove the whole doings for cleaning. The way I clean mine is simply to put the requisite size drills through the cones, holding them in the pin-chuck and poking through by twirling between finger and thumb, whilst any scale in the tapers is instantly removed by an application of the little half-round reamer originally used for reaming the taper.



Pipe connections under drag-beam



Pipe diagram for "Doris"

How to Erect "Doris's" Boiler

The erection of "Doris's" boiler is about the last word in simplicity. All you have to do is to put it on the frames, let the bottom of the firebox wrapper rest on the trailing hornblocks, set the front of the smokebox level with the angle at the front end of the frames, and drop the bottom of the saddle down between the frames until the bottom of the boiler barrel is parallel with the tops of the frames. Run four $\frac{1}{8}$-in. or No. 5-B.A. countersunk screws through the clearing holes already in the frame, into tapped holes in the sides of the saddle; make countersinks with No. 30 drill through the holes, drill No. 40 and tap to suit screws. The rear end of the boiler is stopped from lifting by pieces of angle 1 in. long and clips, exactly as described for "Maid" and "Minx."

A diagram showing the pipe connections is appended and needs no explaining; also a drawing of the drag-beam, showing alternative brackets for carrying the pipes, on a frame which has been built up with angles, screws and rivets. Next week, all being well, I will give details of the grates and ashpans for "Maid of Kent" and "Minx."

RUNNING A HOME FOUNDRY

by A. R. Turpin

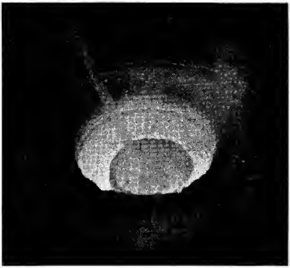


Photo No. 1. *Stirring the melt, with crucible cover removed*

WHEN I first commenced to dabble in foundry work at home, I merely chucked pieces of scrap brass in the crucible, turned on the heat and waited for the metal to melt. Strangely enough, I obtained some quite good castings, and then things started to go wrong for no apparent reason; at least, the reasons were not apparent then, but they are now. So I propose to set out below my method of procedure when melting non-ferrous metals which have turned out reasonably successful. I do not profess to be an expert, and I shall be pleased to receive any suggestions that may lead to improved foundry work in the home.

Photo No. 2. *Pouring an investment casting*

I use the furnace that I described in an article in THE MODEL ENGINEER, December 16th, 1948, using a No. 1 size plumbago crucible which takes about 2 lb. of coppe.. I prefer these to the carborundum type because they retain the heat longer, and this is of some importance when dealing with such small quantities of molten metal, because you need not start pouring in quite such a hurry.

From time to time I shall mention oxidising and reducing atmospheres, and this merely refers to the resultant gases of combustion. If we burn 1 cu. ft. of town coal gas with 184 cu. ft. of air the resultant gases will be neutral; if more air is used the atmosphere will be oxidising, and if less is used it will be reducing. Now this is quite an important point, but, unfortunately, there is no sure way of knowing the resultant atmosphere without an Orzat gas-testing apparatus, and to overcome this difficulty I make sure my atmosphere is oxidising, which is the atmosphere usually desired when melting most non-ferrous metals. I, therefore, turn the gas full on and then increase the air supply until no blue flame burns above the vent.

The reason this care is necessary is because there are two big troubles when melting materials: gas absorption and oxidisation; luckily, one tends to counteract the other. The former results in a porous casting caused by the hot metal absorbing the hydrogen in the reducing atmosphere and releasing it when cooling, which results, in bad cases, of the casting being full of minute pinholes. This is usually indicated by only a slight contraction valley in the risers, and in very bad cases a convex top to them. Now there is less tendency for a metal to absorb hydrogen if it already contains oxygen, so if we use an oxidising atmosphere there will not only

be less hydrogen present but the metal will absorb the oxygen more easily and thus prevent the absorption of hydrogen. Sometimes an oxidising agent is purposely added to the " melt " for this purpose, usually in the shape of a 2 per cent. charge of lump manganese ore, but personally I have not found this to be necessary. Another preventative to stop gas absorption is to melt the metal as quickly as possible, and to pour it at as low a temperature as possible, because the higher the temperature the more easily will a metal absorb gases.

The obvious query now is, why let the metal absorb oxygen more than hydrogen if both are detrimental to the melt? And the answer to that one is—oxygen is more easily removed by other methods.

Some metals oxidise more easily than others, aluminium more easily than zinc, and zinc more easily than tin, and tin easier than copper. A simple test may be carried out to show how easily aluminium oxidises, in the following way:—Cut a strip of, say, 16 s.w.g. aluminium ½ in. × 2 in. long, hold it with a pair of tongs so that it hangs vertically, and then apply a blowlamp flame to it. After a time a bulge will appear at the bottom of the strip; this is the molten metal being held in an envelope of aluminium oxide. Or try melting a crucible full of aluminium swarf, and all you will get is a quantity of grey powder, which is again aluminium oxide.

Now these metallic oxides spoil the mechanical properties of a metal and must be removed; sometimes they can be reduced to the metallic state again, or else removed as dross by skimming.

One method of removing oxide is to add a second metal to the melt, choosing a metal that has a greater affinity for oxygen than the first. Thus, copper can be deoxidised by quite a number of common metals, but care should be taken that any residue will not have a bad effect on the resultant alloy. Thus, the aluminium included in aluminium bronze will automatically deoxidise the copper contents, but to add aluminium to tin bronze even in small quantities would have a very disastrous effect on the alloy, and in this case phosphorus should be used. This is usually added as a 10 per cent. phosphor-copper alloy, but the amateur may have difficulty in obtaining this alloy in the small quantities he requires, and to overcome this difficulty I simply use ordinary phosphor-bronze, which usually contains 3 per cent. to 5 per cent. of phosphorus, and as the amount of phosphorus usually required for deoxidising purposes is from 0.02 per cent. to 0.04 per cent., the addition of about 5 per cent. of phosphor-bronze will be about right.

Now, aluminium oxide cannot be reduced by any commercial deoxidants, so we must make allowance for the aluminium loss, which will be about 1 per cent. or less and get rid of it by dissolving it, using a solvent of the Cryolite type and skim the resultant dross. For this purpose I use a proprietary brand Albral No. 2, supplied by Foundry Services Limited, and I would mention here that I have no connection with that firm, but have found them extremely helpful in all ways.

I usually use a flux when melting all metals, although I have obtained quite good results without their aid, but I would warn readers against using borax and similar fluxes, as they have a very deleterious effect on the crucible and cut down its life very considerably.

I have found that four non-ferrous alloys will meet most of my needs, and these are as follows: Gunmetal (88 per cent. Cu, 10 per cent. Sn, 2 per cent. Zn), aluminium-bronze (90 per cent. Cu, 10 per cent. Al, or 86 per cent. Cu, 10.5 per cent. Al, 3.5 per cent. Fe), the latter having a very high maximum stress; brass, any scrap available; aluminium, scrap piston metal.

As the crucibles are quite cheap, it is advisable to keep a separate one for each type of alloy, and I would warn readers here to mark bronze and brass scrap in some way so that they are not mixed; I paint mine black for gunmetal, red for brass and green for aluminium-bronze. It is very easy to get these mixed and untold trouble will result if, say, the aluminium and tin bronze get mixed.

I repeat, pouring temperatures are important and should be as low as possible. A high temperature means a higher gas absorption and greater oxidisation, the danger of blow-holes and greater liquid contraction.

Too low a temperature will mean a " short run " and lack of surface detail.

Melting Procedure

Aluminium. In all cases let the furnace and crucible reach melting temperature before inserting the scrap, as this means a shorter period of time that the metal will have to oxidise or absorb gases, and for the former reason, keep the pieces as large as possible, so that the surface area exposed to the gases are as small as possible. The melting point of piston metal is round about 620 deg. C. and the pouring temperature 680 deg. C.-730 deg. C., depending on the size and thickness of the casting, a higher temperature being required for a large casting, or a casting of thin sections. I seldom use a flux with this material, and after reaching 20 deg. or 30 deg. C. above melting temperature, I stir, skim and pour.

For skimming purposes I use a spoon-shaped piece of stainless-steel sheet fixed to the end of an iron rod, but any convenient piece of steel rod or strip of sheet iron will do. If an iron crucible is used it should be painted on the inside with a 50/50 mixture of waterglass and whiting; in the best circles the stirring-rods and skimmers are treated in a like manner to prevent contamination.

Owing to the speed at which molten aluminium forms an oxide skin, great care should be taken when pouring it. Hold the lip of the crucible as close as possible to the pouring cup, do not break the flow, and reduce turbulence as much as possible.

Aluminium-bronze. If you are unable to obtain this in the form of ingot metal, it is quite a simple matter to compound the alloy from the virgin metals. I use soft copper bar, which I melt first (melting point 1,080 deg. C.); I then add the aluminium. By the way, the proportions are by weight; this should be 99.0 per cent. pure, and most aluminium cooking utensils are of this purity, so I cut a piece of an old saucepan, and make certain it is quite dry by warming it and add it to the copper; the aluminium will melt

on the surface of the copper, so give it a stir, and at once an intense heat will be generated. I now add flux in the form of Abral No. 2 (Foundry Services Limited), and if I am adding iron, I do so now, using snippets of soft iron wire. The iron may take some time to dissolve, up to, say, 30 minutes ; you can usually feel when it has melted with the stirring-rod. If necessary, allow to cool to 50 deg. C. above the pouring temperature (1,130 deg. C.-1,220 deg. C.), and take the pouring temperature (1,100 deg. C.-1,180 deg. C.), stir, skin and pour.

Brass. For this alloy I use any brass scrap available, and add the phosphor-bronze with the first charge, and here is a point to watch : the phosphor-bronze has a higher melting point than the brass (920 deg. C. as against 980 deg. C.), so see that this temperature is reached, cover with flux (Cuprex Standard), skim, stir and pour at 1,000 deg. C.-1,050 deg. C.

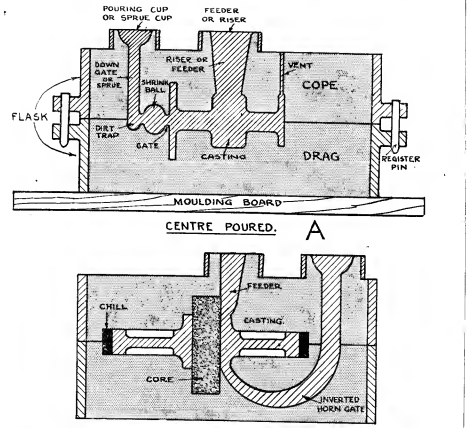


Fig. 1. Illustrating the technical terms used by the author

same pouring precautions as you did with the aluminium alloy.

Gunmetal. This can usually be easily obtained as bar metal, but if not available, melt the copper with the piece of phosphor-bronze for deoxidising, and then add the correct amount of granulated tin (Johnson, Matthey & Co. Ltd.), and follow with the zinc. If you cannot obtain the pure zinc, you can add it in the form of brass ; most brass castings being an alloy of 60 per cent. Cu, 40 per cent. Zn, and it is quite easy to work out the correct proportion of this material to add.

Sprinkle over the top ½ per cent. of flux (Cuprex Standard), bring to 50 deg. C. above

When pouring, always wear goggles or glasses and gloves.

The approximate contractions of the above alloys are as follows : Aluminium-bronze ¼ in., aluminium 5/32 in., gunmetal ⅛ in., brass 5/32 in.

I presume that most readers will know the rudiments of foundry procedure, but as the technology used in this work varies from foundry to foundry I have illustrated in Fig. 1 the terms as I apply them.

Six or seven volumes have been written on this work, and so it will be appreciated that I must leave a lot out and take it for granted that, if the reader is interested, he will pursue the matter

further in his local library. I would point out, however, that 90 per cent. of that written describes difficulties that the model engineer will not encounter, as they are difficulties that arise from size alone. It is quite possible to carry out practices with castings weighing an ounce or so, and get away with what would be fatal if the casting weighed, say, 50 lb. or more.

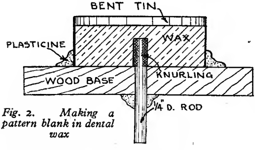


Fig. 2. Making a pattern blank in dental wax

I propose to say little about pattern making, except that which applies particularly to the home foundry. With the small sizes involved it is only a matter of making a replica of the casting required, allowing for shrinkage, and constructing it so that it can be easily withdrawn from the sand without damage to the impression. Coring is very seldom necessary, as the holes are so small that they can easily be drilled or bored without a great expense in extra metal, and often with considerable saving in time.

To obtain a good clean impression it is necessary that a high finish be given to the pattern if of wood, and I usually use one coat of cellulose filler and two coats of high-gloss cellulose paint, rubbing the first two coats down well. Fillets to angles are built up of plastic wood, hard dental wax or plaster of paris.

Sometimes I make the whole pattern of dental wax, and should I desire to cast a blank for a small pulley I would proceed in the following manner (see Fig. 2).

Cut a length of ¼-in. diameter rod, say 3 in. long, knurl one end for ½ in., drill a clearance hole in a piece of smooth board and insert the piece of rod so that the knurled end of the rod projects above the surface, and fix it in that position by means of plasticine on the underside of the board. Now cut a strip of tinplate from an old can, say, 1 in. wide, and bend this into a circle slightly larger than the desired blank, and fix it on the surface of the board by means of more plasticine concentrically to the rod. Fill the receptacle so produced with molten wax and allow to set really hard. Allow a thicker disc than you want, to compensate for shrinkage, and then remove the tin surround and carefully push up the rod from beneath the board, pulling on the disc of wax at the same time; if the board has been well oiled previously the wax will come away easily with the rod embedded in it. Chuck in the three-jaw and turn to the desired shape, and I would mention here that wax is the most delightfu material I have ever tried turning in the lathe.

To remove the rod from the pattern, heat the end farthest from the wax and the heat will soften the wax so that the rod may be removed without damage to the pattern. The hole left may be filled up by means of a hot piece of pointed rod and a strip of wax, in much the same way as you would use a soldering iron and solder.

If desired, the wax disc can be parted from the rod to form a ring by using an ordinary boring tool. These wax patterns would never stand up to the treatment patterns usually get in a commercial foundry, but at home it is possible to use them three or four times with care.

Dental wax is rather expensive, and a cheaper substitute is ordinary candles four parts, resin one part; or, better still, carnauba wax ten parts, paraffin wax (50 deg. C.) 35 parts, beeswax 55 parts. The wax model may be polished to a high degree by merely rubbing the finger-tips on it whilst revolving it in the lathe.

Patterns should be given as much draft (taper) as possible without spoiling the efficiency or the appearance; this makes the withdrawal much easier, minimum is about 1 degree. When symmetrical patterns are being made, considerable time can be saved later on if they are constructed as split patterns, as this saves making "odd-sides," which I will explain later. Actually, this takes very little longer if the block of wood to be used is made up of two pieces dowelled together and glued at each end, the wood having sufficient extra length for the glued portions to be sawn off when the pattern is finished.

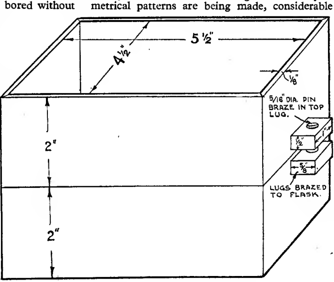


Fig. 3. The moulding flask

If the pattern has fine detail, that can easily be filed or milled; it is sometimes better to make a rough casting in brass from a semi-finished

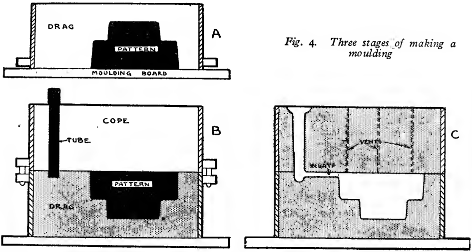


Fig. 4. Three stages of making a moulding

pattern in wood or wax, and then finish off this casting as the pattern proper; but this will usually only apply when a number of castings are required from the same pattern. At other times, a composite pattern of wood and wax can be used, any fine detail being carved in the wax, such as a crest or the like.

Having made your pattern, the next things required are foundry sand, core sand, parting powder, flasks (moulding boxes), a riddle, moulders' trowels, an old egg-spoon, rammers, striking board, rapping-rod and a moulding board.

Casting Sand. This should be a fine sand such as Mansfield or Erith, and unless you happen to be friendly with a foundry you may have the same difficulty as I did in obtaining it in small quantities of, say, 14-lb. lots.

I found out, however, that people like the Dental Manufacturing Co. Ltd. make up 14-lb. bags of moulding sand for casting gold dental plates, and I have found this excellent for making non-ferrous castings.

The sand arrives quite dry, and to prepare it for use it must be mixed with about 6 to 8 per cent. of water. This I do by spreading the required quantity of sand out on an old metal tea tray and using a sprinkling bottle, the same kind as my wife uses when ironing. After the watering, mix the sand up well and leave for an hour or so. When a quantity of it is grasped in the hand, it should hold well together and break cleanly. If too little water is used, the sand will not hold together, and if too much is used, there will be a loss of porosity, and the casting will suffer from blowholes. Spluttering at the pouring cup clearly indicates too moist a sand. This only applies to green sand castings; with baked moulds, the sand can be used much wetter and practically all my castings are made in baked moulds, or perhaps I should say dry sand moulds.

For coring, I merely mix the same sand with 5 per cent. of linseed oil, and it is imperative that the sand is well mixed; then bake the cores in an old biscuit tin until hard; start the baking process at a low heat, about 100 deg. C., and then gradually raise it to 250 deg. C. maximum. I can give no times for this process, as it depends

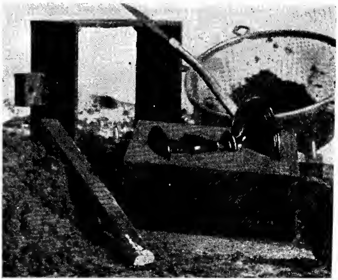


Photo No. 3. Making an "oddside" of a cup stem

so much on the size of the core; it may be anything from thirty minutes to four hours.

Parting powder is placed in a muslin bag and dusted over the two halves of the mould so that they do not stick together, when the second half is rammed. Various materials can be used for this purpose—bone dust, burnt sand, lycopodium, or one of the many proprietary parting powders, which are usually excellent.

The flasks I use are home-made, because the smallest commercial sizes are too large for most model work. The flask should be of such a size that at least half an inch separates the pattern from the sides of the flask, and this includes the sprue, etc. The size I found most useful is one measuring $4\frac{1}{2}$ in. × $5\frac{1}{2}$ in. × 2 in. deep, that is the measurement of each half.

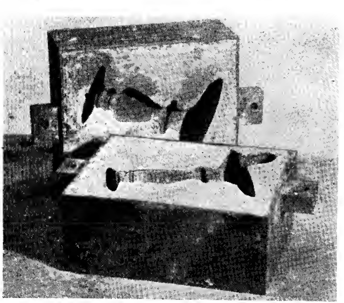


Photo No. 4. The finished oddside mould

I made my flask from 2 in. × $\frac{1}{8}$ in. mild-steel strip, mitring the corners and then brazing them (see Fig. 3). Lugs are then brazed on to the ends in the positions shown, the two halves clamped together and $\frac{5}{16}$-in. holes drilled through the lugs; bluntly-pointed pins are then brazed in the "cope" portion to locate it with the "drag."

The riddle that the professional moulder uses I have found to be too large, and if you can obtain one about 8 in. diameter, that would be about right. I was unable to find such a sieve, and used a vegetable strainer made of wire. The mesh is rather fine—about $\frac{1}{8}$ in.—for quick working, but all the better if you have the time to rub the sand through; $\frac{3}{16}$-in. mesh would be better.

The moulders' trowels are really miniature ones and are easily made from small pieces of thin spring-steel brazed to bent pieces of iron rod. Various shapes are required, heart, oval, square, etc., most of them about an inch or so long and half an inch wide. The egg-spoon is for cutting ingates, and is an excellent tool for this purpose. To ram the sand, a piece of hard wood $\frac{1}{2}$ in. × 1 in. × 8 in. long will do, and a block 3 in. square to finish off with. To "strike" off the top of the flask level, any straight piece of wood or metal will do, and the moulding board is merely a flat piece of wood, say, 1 in. thick and somewhat larger than the flask to be used. The rapping-rod is a piece of $\frac{1}{4}$-in. diameter mild-steel rod, pointed at one end and 6 in. long.

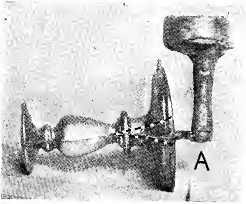
Now let's try to make a mould of, say, a backplate like Fig. 4A. Place it on the moulding board, large face down, with the drag surrounding it. Lay it off centre to allow for the sprue and ingate, riddle sand over it until it makes a heap to the top of the flask, then press it firmly round the pattern with the hands. Fill to the top again with sand, using a large trowel this time, and ram down firmly with the rammer, and repeat until the sand fills the flask slightly above the top. Hammer all over with the square block of wood, and then level off with the striking board.

Now turn the flask over and dust with parting powder, blow away the surplus—bellows are handy—and fix the "cope" in position, locating it with the registration pins. Push a piece of tubing into the sand, say, $\frac{1}{2}$ in. away from the pattern, just sufficiently to make it stand vertically (Fig. 4B), and riddle a layer of sand over the top of the drag. Press it down as before, and then completely fill the "cope," ramming it and striking it level as previously described. The piece of tubing should now be sticking out above the sand. Rock it slightly and withdraw it, and then, whilst holding the "cope," gently tap the moulding board, and the "cope" can be lifted off the "drag." If the "cope" is too large to hold with one hand, you will need an assistant for the last operation. By the way, before removing the "cope," a pointed piece of wire, say, 16 s.w.g., should be pushed through the sand almost to the pattern in half a dozen places, to vent it.

Now comes the tricky part, getting the pattern out of the sand without breaking the mould. Take the pointed rapping-rod and stick it into the centre of the pattern, tapping it gently to do so, and then pressing down on top of the rod, tap it sideways in all directions; this will loosen the pattern in the mould, and it should then be possible to lift out the pattern by means of the rapping-rod. You will find that the edges may have been lifted slightly, and this can be prevented to some extent if the sand around the edges of the pattern are moistened by means of a camel-hair brush dipped in water before trying to remove the pattern. However, as soon as the pattern has been

lifted, it is as well to replace the " cope " so that any edges lifted are pushed back into place ; this is better than trying to dress them with one of the trowels.

The spot where the tube was pushed into the sand will show up, and we now cut the gate with the aid of the egg-spoon. This is merely a trench



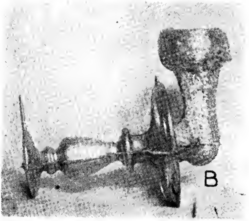


Photo No. 5. Contraction in a wine cup stem

which connects the downgate, i.e., the hole left by the tube, with the hole left by the pattern. Blow away all loose sand, replace the " cope," and we are ready to pour (Fig. 4C).

Now, if we have a pattern as shown in Fig. 1A, it is obvious that we can't treat it as we did the last pattern, and so we must proceed as follows. Fill the " cope " with sand, turn it over, and scoop out a depression. Place the pattern in the depression, pushing it down into the sand until the half-way or parting-line is level with the edge of the " cope," then fill in with sand all round it, and level off smoothly with a suitable trowel so that it looks like photograph No. 3. Dust with parting sand and place the " drag " in position over it, carefully ramming with sand. We are now apparently ready for pouring (if we had not forgotten the gate), but the pattern was only put in the " drag " in the first place for support, and if we tried to pour the metal now, even if there was a gate, we should find that the sand was not properly bedded in below the pattern ; so what we do is to turn the whole thing over, carefully remove the " cope," leaving the pattern in the " drag," remove all the sand from the " cope " and refill carefully as before, not forgetting the sprue (photograph No. 4).

It will be seen that an oddside mould takes considerably more time, and unless the pattern is buried exactly at the correct parting-line it will be impossible to withdraw it without breaking the edges of the mould. If, however, the pattern is made in two halves as previously described, it may be treated in the same way as we did the backplate pattern, the only difference being that when we have rammed the " drag " we place the second half of the pattern in position.

The second way of overcoming the trouble of making an oddside moulding is to make a permanent oddside in plaster of paris. To do this, make a shallow box slightly deeper than half the depth of the pattern, and slightly larger than the flask, fill with plaster of paris, oil the pattern and press it into the plaster, then leave it there until the plaster has set. Remove and sandpaper down flat to the parting-line The plaster mould is now used to hold the pattern whilst the " drag " is being rammed, and it can, of course, be used over and over again ; this procedure is not worth while

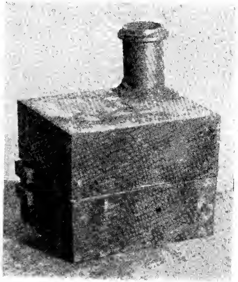


Photo No. 6. Extension sprue to give greater head to the molten metal

unless there are a number of castings required from the same pattern.

We now come to the important part of moulding, and that is the disposition of the sprue, gates, vents and risers, or, if you like, pouring basin, runners, feeders ; foundrymen do not seem able to make up their minds on such matters.

If we fill a tube with molten aluminium and allow it to solidify, a depression will form in the top, and this depression will be greater than if

the tube was filled with, say, bronze. This is the liquid contraction of the metal.

In the case of the casting of a pulley blank, shown in Fig. 1B, this contraction would cause considerable trouble because the spokes would solidify first, and there would be no means of feeding more metal to the rim as it froze and contracted, and it would distort badly. The same would occur at the boss.

In the case of the boss, we arrange a feeder for this, which must have a greater cross-section area than the boss, otherwise it will freeze first and become inoperative, especially as in this case we have arranged for bottom feed. This helps to prevent turbulence and occlusion of oxides when dealing with aluminium or its alloys, because the metal in the feeder will have travelled farther than the metal in the boss and have cooled down more. The necessity of large feeders may be overcome by pouring into the sprue cup until the metal shows about a third way up the feeder, and then continue to pour the hot metal into the feeder. In this way we can overcome the liquid contraction distortion in the boss, but in the case of the rim we should want a number of feeders round it, and this would mean a lot of extra metal in the melt, so we tackle the problem from a different angle, and make the rim freeze before the spokes.

To do this, we place an iron ring round the mould where the rim will come, and this will chill the metal so that it freezes before the spokes. The ring, which may be in, say, three segments, is placed round the pattern before the sand is rammed.

Sometimes liquid contraction does not appear as distortion in the casting, but as a cavity which may not be apparent until machining has taken place, or it breaks at that point. Such a cavity occurred in the casting of the wine cup stem shown in photograph No. 5, the position of the cavity being shown by the dotted line in "A." This was caused by the bulbous portion remaining molten longer than the remainder. To arrange a feeder or a chill for this portion would not be easy, so the alternative arrangement shown in the photograph at "B" was used. This merely consists of increasing the size of the ingate, and downgate, so that the larger volume of metal kept the base and neck molten until the bulbous portion had frozen.

The best place for a gate is in the top of the casting, where it can then be of such a size that it acts as a feeder as well, and in small castings this can often be arranged; but in the case of large castings a gate in this position causes turbulence and perhaps damage to the mould, as the metal drops from a considerable height on to its bottom. These two faults of top pouring can be overcome by arranging a number of ingates from one downgate, one at the bottom, one half-way up the casting and one at the top.

Although the porosity of the sand will allow quite a lot of air to disperse through it, it is as well to arrange vents at the main high points in the mould by pushing a knitting needle through at this point to the top of the flask.

To obtain a casting with good sharp corners and fine detail, it is necessary that there should be a good head of metal, about 4 in. if you can get it, and in order to obviate the use of very deep flasks I usually make an extension to the sprue by means of a piece of piping, as shown in photograph No. 6. The piece of piping should be filled with sand and a hole made through it, otherwise the bare metal would cool the molten metal too much in a small casting. The pipe is then fixed in position over the existing sprue hole by means of more sand.

In order to give a better surface finish to castings, a mould wash is often used. This wash is applied to the mould in the green state, either by spraying or by means of a camel-hair brush. There are numerous materials that can be used, including countless proprietary brands. Two of the more common are a 50/50 mixture of plumbago (graphite) and china clay, mixed to a creamy consistency with water, or a second mixture is nine parts water, one part sodium silicate, and sufficient lamp-black to form a cream.

In order to prevent any chance of blow-holes, I invariably dry my moulds either in an oven made from a biscuit tin, or more often by standing in two halves of the flask on either side of the furnace vent whilst melting the metal.

With a properly designed pattern and mould, the two chief troubles that the beginner is likely to encounter are loose pieces of sand getting in the casting, and poor detail through pouring at too low a temperature. I have found it better to remove any pieces of the mould that show a tendency of breaking away if they are small, because it is always possible to file off a lump of metal where the sand broke away, but nothing much can be done to a casting which has a piece of sand embedded in it. It is sometimes possible to fill such a hole with silver-solder, but more often it is not.

The second reason, pouring at too low a temperature, is brought about because the beginner does not appreciate how long it takes for a metal to reach pouring temperature after melting point is attained. It will, of course, vary from furnace to furnace, but in my own case I find that if it takes twenty minutes from cold to melt a crucible of brass, it may take as long as six or seven minutes more to raise the temperature another 150 deg. C.

In conclusion, I would point out that when I first started taking an interest in foundry work, it appeared from what I read that it would be quite impossible to get results without complicated testing instruments, and I almost gave up the idea of a home foundry; then I had reason to visit a few small jobbing foundries. In most cases these foundries were run without any kind of laboratory, not even a pyrometer, and yet they turned out what appeared to be reasonably good castings. They did, however, have experience.

My experience has been gained entirely at home, and if any other readers, especially the experts, have any suggestions to offer, I shall be very pleased to receive them.

By the way, in photograph No. 2, I have shown an investment casting being poured, and some readers may wonder why I have not mentioned this. Well, investment moulding is a foundry process which is gaining ground rapidly for certain types of castings.

Tales of a Tyro

by Edward Adams

TWELVE years in building small locomotives may not be anything of a record, but even that period has provided many laughs, something like tears at times, and a host of unforgettable memories.

Starting from scratch and with a minimum of experience with a lathe and other tools, I have learnt many things, perhaps the most valuable being how to avoid making mistakes. Not that one is always successful; mishaps come now and again, to leave one sadder and wiser, or it may be only sadder.

Especially is this so if one has a liking for experimental work; the unexpected quite often happens—to me at all events. As an instance of this, in my innocence, I once had castings made in gunmetal for sixteen driving wheels, turned, fitted and coupled them and completed the locomotive, only to discover, with dismay, incurable wheel slip on the brass track. The painful remedy was, of course, to start all over again with castings in iron—with what feelings can best be imagined.

On these ill-fated occasions, it is usual for other members of the family to hear a one-sided conversation going on in the workshop and to be accused of talking to oneself—and with what language!

Fortunately, there are lighter moments, enriched by the blessed gift of laughter, as when the kindly postman, looking round the door of my workshop at a number of coal-fired locomotives, remarked, "Very interesting; all electric, I suppose?"

Again, the comment of a lady to her husband, after seeing one of my locomotives running on the track, "Did he make it all himself? He is such a nice chap too." The exact meaning of which has so far escaped me, but makes me chuckle whenever I think of it.

A small and slightly precocious boy, on being shown four or five of my $2\frac{1}{2}$-in. gauge locomotives, several years in the making, asked, "Is that all you have to show me?"

Small boys are often very interesting, however. Occasionally they come in twos and threes to take part in a running. Some have never before seen a small coal-fired locomotive at work. What rapture to stoke a real fire with a real shovel and real coal, or to fetch water and fill the tender tank. Oiling the motion is also an absorbing job. To drive her and toot the whistle—Heavens, what joy unspeakable! They go home as black as tinkers, to the dismay of their mothers, no doubt, and the little ones sometimes burst into tears at having to part. After a few minutes' instruction, when high spirits have settled down somewhat, I usually retire to a safe distance and watch the fun, being at hand in case anything goes wrong. It soon becomes obvious who are the potential engineers, and it is seldom necessary to interrupt them.

Railwaymen's old caps, of which I have a number, are also very popular. The boys wear them as to the manner born, often many sizes too large for their heads, with comical results. Oddly enough, the stationmaster's cap is not the best liked, notwithstanding the gold braid. Adult visitors to the railway have been known to wear them—on one occasion a clergyman.

Some years ago, I gave several talks to boys' schools, sugaring the pill of instruction on the history and mechanics of locomotion with the excitement of getting up steam in a small locomotive and seeing it work. The usual procedure was to send three engines of different types to the school a few days before the talk was due to take

place. A friendly master would then show the locomotives to the boys and prime them on suitable questions to ask me. When I did arrive and had duly said my piece, it was really remarkable what a number of questions were fired at me, often difficult to answer to the satisfaction of the questioners, such as the working and effects of various valve-gears and their notching up, about

(*Continued on page 363*)

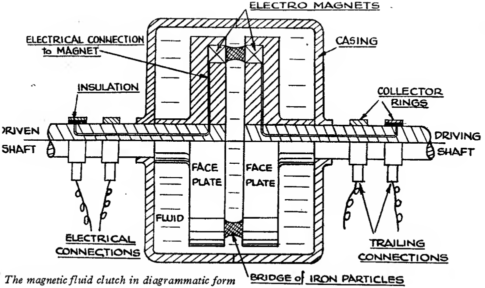
THE MAGNETIC FLUID CLUTCH

by T. A. Brown, A.F.R.Ae.S.

A NEW clutch has recently been developed by the National Bureau of Standards in America. The principle on which it works is that a magnetic force acting on certain types of fluid can control the frictional forces developed between revolving metallic surfaces. In actual practice, the clutch takes the form of a driving and a driven shaft on which plates are mounted. These plates are submerged in oil, in which millions of fine iron particles are suspended. When a magnetic force is applied, these iron particles attempt to bridge the gap between the magnetised driving and driven plates, thus tending to bind them together. Due to the working surfaces being totally immersed in oil, wear is negligible.

Other assets of the magnetic fluid clutch are that it operates without the chatter that is so difficult to avoid with the dry-friction type ; it is easy to control, and shows no tendency to grab. Another advantage that it has over the dry-friction unit is that its frictional properties remain almost unimpaired with use over extensive periods of time. With the dry type of clutch, wear inevitably leads to a reduction in the locking forces, and eventually to slipping ; but the new fluid clutch gives an almost constant locking force.

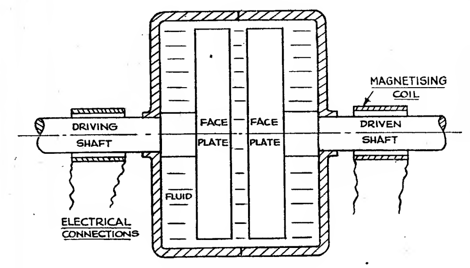
Although this principle has been applied in practice to clutches only, it has numerous possibilities in other fields. It could, no doubt, be employed in brake design, and the automatic control of machinery. Since it is operated magnetically, it lends itself to remote control, and this is one of the features that will ensure its many applications in industry in the near future, for it can be controlled either manually or by a hand switch, or automatically by means of time clocks. Since it is operated electrically, the need for long operating-rods, giving backlash caused by wear or other mechanical linkage, is avoided.



The magnetic fluid clutch in diagrammatic form

Briefly, the operation is by means of an electric current conveyed through the medium of collector rings on the driving and driven shafts, to electro-magnets built into the revolving faceplates on these shafts. The current is conveyed from one collector ring through the shafts and faceplates, and into the windings of the coils, which surround the soft-iron cores of the electro-magnets. The electrical circuit is then completed by wires from the windings of the coils to a second collector ring. The action of the electric current sets up a magnetic field between the driving and driven faceplates, and pulling the iron particles out of suspension in the surrounding oil, causes a bridge of iron particles to be formed, and a locking force to be produced between the driving and the driven shaft.

Model engineers wishing to use the magnetic fluid type of clutch could probably simplify the construction by the removal of the collector rings and electro-magnets and replacing them with a magnetising coil around the driving and the



A simplified version of the clutch

driven shaft. These shafts would thus act as the cores of the electro-magnets, and the plates would therefore be magnetised. It should be remembered, however, that the magnetising coils should be so arranged as to produce opposing poles and, therefore, an attraction between the driving and the driven faceplates. This is easily effected by rearranging the electrical connections to the magnetising coils until the desired result is obtained.

Tales of a Tyro

(*Continued from page* 361)

which even the lecturer was often rather hazy; and no one is more critical of being led up the garden path than the average small boy, with wide eyes and face all innocence.

"Nobby" Also Ran

But the crowning event was the actual running under steam of "Nobby," a 2-2-2 engine, which would race up and down the Assembly Hall floor without rails. Then masters and even school inspectors have been known to forget their years and, for a few minutes at least, thoroughly enjoy themselves.

After one of these talks, the headmaster and I were chatting in his study when, looking out of his window with a wistful eye, he enquired, "Is there room for a railway track against that fence, do you think?"

Arising out of one of my school talks, a group of boys, with the guidance of a sympathetic master, decided to build a stationary engine and boiler, beginning with their own drawings and blueprints—I believe they even sensitised the paper—making small tools and lastly the actual model, which I saw at completion and was astonished at the quality of the work. Not bad for boys who had scarcely used a file before, and a useful introduction to what, for many of them, would be their life's work, in this engineering centre.

Coal

For those of us who live in the North, South Wales steam coal is not easy to come by. One of my locomotive friends, armed with sixpence and a large paper bag, used to meet a train from South Wales at a local station, there to barter with an obliging fireman for a lump or two, to their mutual satisfaction.

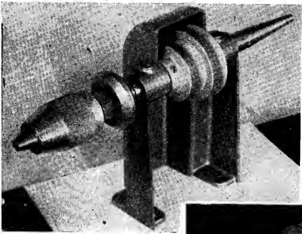
Hearing of a coal yard where the desirable fuel was to be found, I myself have taken a taxi to it, the fare costing me much more than the coal.

Having almost given up hope of procuring Welsh steam coal locally, a large heap was espied in a neighbour's garden, not twenty yards away. Moreover, the owner had little use for it and was quite satisfied to exchange it for an equal quantity of the household variety.

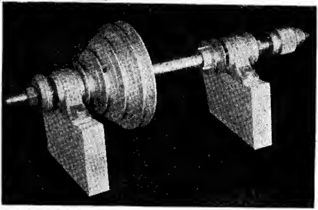
But one could go on with these yarns indefinitely, touching as they do upon the human side of our craft, than which there is surely no more fascinating occupation in the world.

New Tools at Gamages

THE increasing use of light alloy die castings in the construction of workshop equipment is exemplified in new items submitted to us by Messrs. A. W. Gamage Ltd., Holborn, E.C.1, namely, a grinding and polishing head and a saw and grinding spindle. The former is constructed of light alloy castings, with a ⅝-in. diameter steel spindle running in oilite bushes and carrying at the grindstone end, a 0-½-in. chuck. A 2-step Vee-pulley is fitted between the bearings. The saw and grinding spindle is again of light alloy construction, the bearings in this case being plummer blocks with oilite bushes. The model under review has a ⅝-in. diameter shaft threaded left- and right-hand at the ends, with the addition of a 0-½-in. chuck, a 4-step Vee-pulley and a small single pulley for high speeds. The pulleys, single and stepped, and plummer blocks are obtainable in a wide range of sizes, enabling countershafts, spindles, etc., to be built up quickly and with ease.

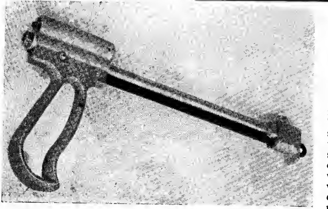


Left—A grinding and polishing head with die-cast frames and pulleys



A sawing and grinding spindle incorporating light alloy die castings

The disadvantages of the ordinary hacksaw when applied to sheet metal work, particularly in respect of its limited depth of cut, are ingeniously surmounted in the new "Padhacksaw," which takes a standard 10-in. hacksaw blade, and in use, there is no frame to pass over or through the work, yet the blade is substantially supported throughout the cutting stroke, by a rigid bar equipped with means of holding and tensioning the blade at the outer end. The blade can be given the same pressure as though it were under tension in an ordinary frame saw, and the absence of a frame enables the user to cut large holes which necessitate starting the cut within the hole, profiles, corners, etc. A keyhole or padsaw blade may also be fitted to the stock, in place of the blade and tension bar.



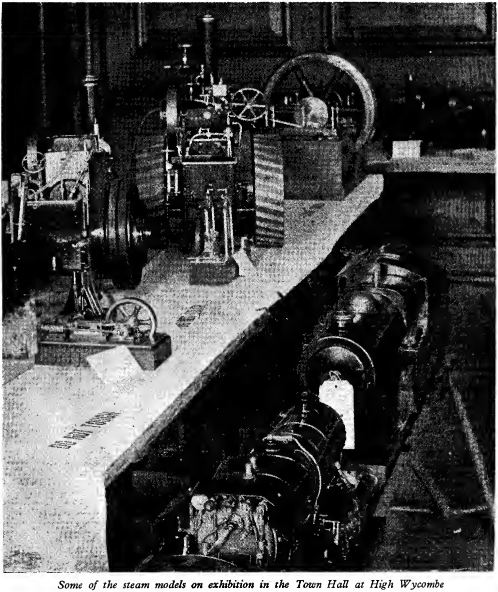
The "Padhacksaw" for cutting sheet metal

Model Exhibition at High Wycombe

MR. A. GALEOTA reports that the High Wycombe Model Engineering Society's recent model exhibition in the Town Hall was most successful, and many thousands of visitors admired the magnificent display of models.

Members of the Slough Model Engineering Society also exhibited and, in the engineering section, first prize was awarded to Mr. H. W. Varney for his locomotive. Mr. F. Hands, of High Wycombe, was given second prize for his "Petrolea." Many of the already well-known models were on show, among which the "Princess Marina" and the "Royal Scot," owned by Mr. F. Hands and S. Wade, and the magnificent tractor built by Mr. G. T. Williams.

The shipping section contained many fine models, among which was a unique radio-controlled and electrically-propelled river launch,



Some of the steam models on exhibition in the Town Hall at High Wycombe

an exceptional work by Mr. G. T. Peck. In this section the first prize was awarded to Mr. R. Dimmock for his 36-in. galleon, a fine example of planked construction; this is actually a sailing model. Very realistic, too, was his river steamer *Marlow*, driven by a powerful electric motor. A special prize was given to Mr. H. A. Gibbs for his R.A.F. tender.

The model aeroplane section included a complete range of all types of aircraft, from miniature free-flight types to the gigantic ½-full-size "Taylor Cub," built by Messrs. Wade and Rackstraw. Original and outstanding was a 36-in. span line-controlled Vickers Viking powered by two "ED" compression engines and fitted with a special retractable undercarriage, work of Mr. H. A. Gibbs. This model secured the challenge cup offered by Mr. Wade. Worthy of special mention were also a "privateer junior" built by Miss Roma Morgan, and various gliders and petrol models built by Mr. A. Day. Much praise and congratulation is due to the Hon. Secretary of the Society, Mr. E. J. Szlumper, for the fine organisation and success of the show.

PRACTICAL LETTERS

The "Eureka" Electric Clock

DEAR SIR,—The articles now appearing on the "Eureka" electric clock are, to me, of particular interest, but there is one point to which I would draw the attention of both "Artificer" and intending constructors.

On page 201 of the issue dated February 17th, 1949, "Artificer," in describing the construction of the balance wheel, states, "A solid rim may be used, preferably with steel . . . and in this case the subsequent splitting of the rim will not be necessary."

I would point out that a *solid steel* rim in conjunction with the case of the electro magnet will form a closed magnetic circuit and render ineffective the electro magnet as a means of driving the balance wheel.

One way to overcome this would be to omit the cone and winding in the balance wheel and have a fixed electro-magnet underneath the wheel in place of the fixed armature.

Yours faithfully,
Grange-over-Sands. G. R. WALLACE.

DEAR SIR,—I would like to express appreciation of the most interesting articles in THE MODEL ENGINEER by "Artificer," dealing with the "Eureka" electric clock.

It was a completely new mechanism to me until he commenced the present series, and that enormous balance-wheel with its poise screws made a great appeal as soon as I saw the photographs.

Personally, I am greatly interested in the old bracket clocks with verge escapement and engraved backplate, and am rather indifferent to the usual pendulum-controlled electric clocks, which, incidentally, seem to appeal to many readers, judging from the fine examples at numerous "M.E." Exhibitions.

This "Eureka" clock, however, is a most fascinating timepiece from the model-engineer-cum-clockmaker viewpoint, and I feel most grateful to your contributor for "discovering" it and writing these articles for readers' benefit.

I would like to raise one query, which I feel will probably be a "silly question"—however, the point is :—

Regarding silver-soldering the outer brass rim to the steel inner one, to construct the compensated balance; will there not be a tremendous hidden stress locked in the composite wheel when the solder solidifies and the rim continues to cool down to atmospheric temperature?

Presumably, when the rim is cut the two parts would curve outwards and the wheel would be always well out of circular truth at ordinary working temperature.

Probably it would not matter if this *was* the case, but I imagine there must be some factor I have overlooked.

Incidentally, I came across one of these clocks in a small bookshop specialising in horology, in the West End—the owner of the business appears to do a little practical work in addition, and he most kindly showed me the movement in action. He mentioned that he had had some trouble with the contacts, but everything appeared to be functioning well at the time.

Perhaps my small point could be cleared up in one of the future articles in THE MODEL ENGINEER.

Yours faithfully,
Ealing. JOHN C. STEVENS.

Power Tools from R.A.F. Motors

DEAR SIR,—With reference to my article in THE MODEL ENGINEER, No. 2487, of January 20th. Perhaps I may be forgiven for taking the liberty of answering a question which has been common to the many enquiries I have received, i.e., "Where can I obtain these motors?"

In the first place, my article was written in March, 1948, and at that time the motors used (Rotax Controllable Gill Operating Motor, type C.1306) were available as *ex*-R.A.F. surplus.

Unfortunately, I do not know of a source of supply at the present time, but maybe some reader could help in this connection through the medium of this page.

It is obvious from the interest shown that R.A.F. surplus material is certainly to the fore in the modelmaker's search for ideas, and I am of the opinion that more articles such as "Swords into Ploughshares" by "Artificer" would be welcomed by many readers.

Yours faithfully,
Rishton. C. LAW.

"Minicar" Construction

DEAR SIR,—I was interested in Mr. John H. Ahern's letter in your issue of February 24th.

While I once felt that with new cars in such short supply we might soon be forced to build our own, I do not think minicar construction will be found very profitable to the model engineer.

As Mr. Ahern observes, people were building their own vehicles about thirty years ago—I remember that before the 1914-18 war THE MODEL ENGINEER published details for just such a cyclecar. But it must be remembered that in those days secondhand cars were less reliable and easy to acquire than they are today and that the light cyclecar, usually with a lusty V-twin engine, offered performance that was brisk in comparison with that of the conventional, but appreciably heavier, small car.

I agree with Mr. Ahern that a two-cylinder motor-cycle engine and chain-drive to a solid back-axle would be satisfactory and that 30-35 m.p.h. would suffice on short runs; after all, the slower your car, the more motoring you get from your ration of petrol!

I do not think the home-brewed minicar has a future, however, because it is more straightforward, easier, and nearly as entertaining to acquire a second-hand car, and overhaul and modify it. For example, a touring Austin 7 of 1927-1930 vintage can be obtained, even today, for £25 to £50 according to condition. If a later four-speed Austin 7 engine-unit is installed, which is by no means a major operation, a brisk, economical, smooth-running car results, able to carry three persons and climb almost any hill likely to be encountered. It can even be used by the would-be competition driver in simple trials, without fear of disgrace.

Now by the time Mr. Ahern has bought and overhauled his motor-cycle engine-unit, has acquired the parts essential to a reliable transmission, safe steering and effective braking, plus special wheels and tyres, and *has built a body* for his minicar, I suspect he will have spent as much as he would have done on the aforementioned Austin 7, or similar, conversion.

He will merely have a far slower, highly-experimental vehicle, probably with no greater degree of comfort or weather-protection. He may argue that whereas the Austin will only give 40-45 m.p.g. his vehicle will do 50-60 m.p.g. Against that, he will be paying £10 a year in taxation in comparison with the £5 a year he would pay had he built a three-wheeler (or £5 against £2 10s. if using only the standard petrol ration), so it seems illogical to go in for four wheels if economy is the aim.

I realise that if economy is *not* the aim, putting a big engine in an ultra-light chassis (perhaps constructed of wood, with bicycle-like wheels) might produce a turn of speed that would leave the Austin behind—but for how long and up to what sort of hills is a matter for conjecture.

For these reasons I do not think we need fear a shortage of good model locomotives, steam-engines and boats, etc., because model engineers have decided to devote their energies to building minicars. With second-hand prices falling, the renovated used car is much the safer bet.

But I will admit that to the model engineer who is also a motoring enthusiast, the idea of a self-constructed cyclecar is fascinating. Those who have the necessary imagination—or lack of imagination—to wonder how a big single-cylinder air-cooled engine would propel a very light single-seater, and what m.p.g. would be realised, might be induced to forsake model building to find out. But if inexpensive or exciting motoring is the requirement, then the overhauled second-hand Austin or an overhauled Morgan three-wheeler, respectively, fill the bill.

I shall, nevertheless, watch with interest for any designs Mr. Ahern's interesting letter may bring forth.

Yours faithfully,
Fleet. W. BODDY,
Editor, *Motor Sport*.

Now the "Minicar"?

DEAR SIR,—I was very interested in Mr. John H. Ahern's letter in THE MODEL ENGINEER regarding the "Minicar."

He expresses a little difficulty about a simple but effective transmission. A little farther on in the same issue, I noticed that somebody was advertising *ex*-W.D. pumps for sale.

Now, my suggestion for a simple transmission would be to couple a variable-output hydraulic pump directly to a small motor-cycle engine and an oil motor to each of the rear wheels, or to all four if preferred, and couple the whole lot up with high-pressure rubber tubing. This dispenses with gearbox, clutch and transmission at one fell swoop, and we have in effect an infinitely variable gear. I do not know the exact principle of operation of the oil motor, but it might just be possible to use these as brakes also, by having a valve, controllable by foot pedal, in the oil circuit to resist and shut off the back-pressure of the oil motors when it is desired to stop the car.

With this method of transmission, a little imagination will show a number of other easily adaptable gadgets such as speedometers which work by the measurement of oil flow, and it greatly simplifies the fitting of independent springing, etc.

Most model engineers are interested in all things mechanical, and to those of us who have the desire but not the money to possess a small car, this idea may be interesting. I do not know the history of motoring or whether this idea has ever been tried before, but to me it certainly seems a workable proposition.

Yours faithfully,
Darlington. P. SKERRY.

Valve-gear for "Annie Boddie"

DEAR SIR,—May I, through the medium of your journal, appeal to any reader who can help me with details of Walschaerts valve-gear for "L.B.S.C.'s" locomotive "Annie Boddie." I am willing to pay for any drawings, or defray any expense incurred.

1, East Road, Yours faithfully,
Gorton, Manchester, 18. J. WOOD.

(We believe that a number of builders of "Annie Boddie" have fitted Walschaerts valve-gear and may have drawings which could be loaned to our correspondent.—ED., "M.E.").